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# Electronics

HE WORLDWIDE TECHNOLOGY WEEKLY

DECEMBER 23, 1985

## A BIPOLAR PROCESS THAT'S REPELLING CMOS

**TI's SPEEDY IMPACT X USES TRENCH ISOLATION TO BUILD DENSER CHIPS**
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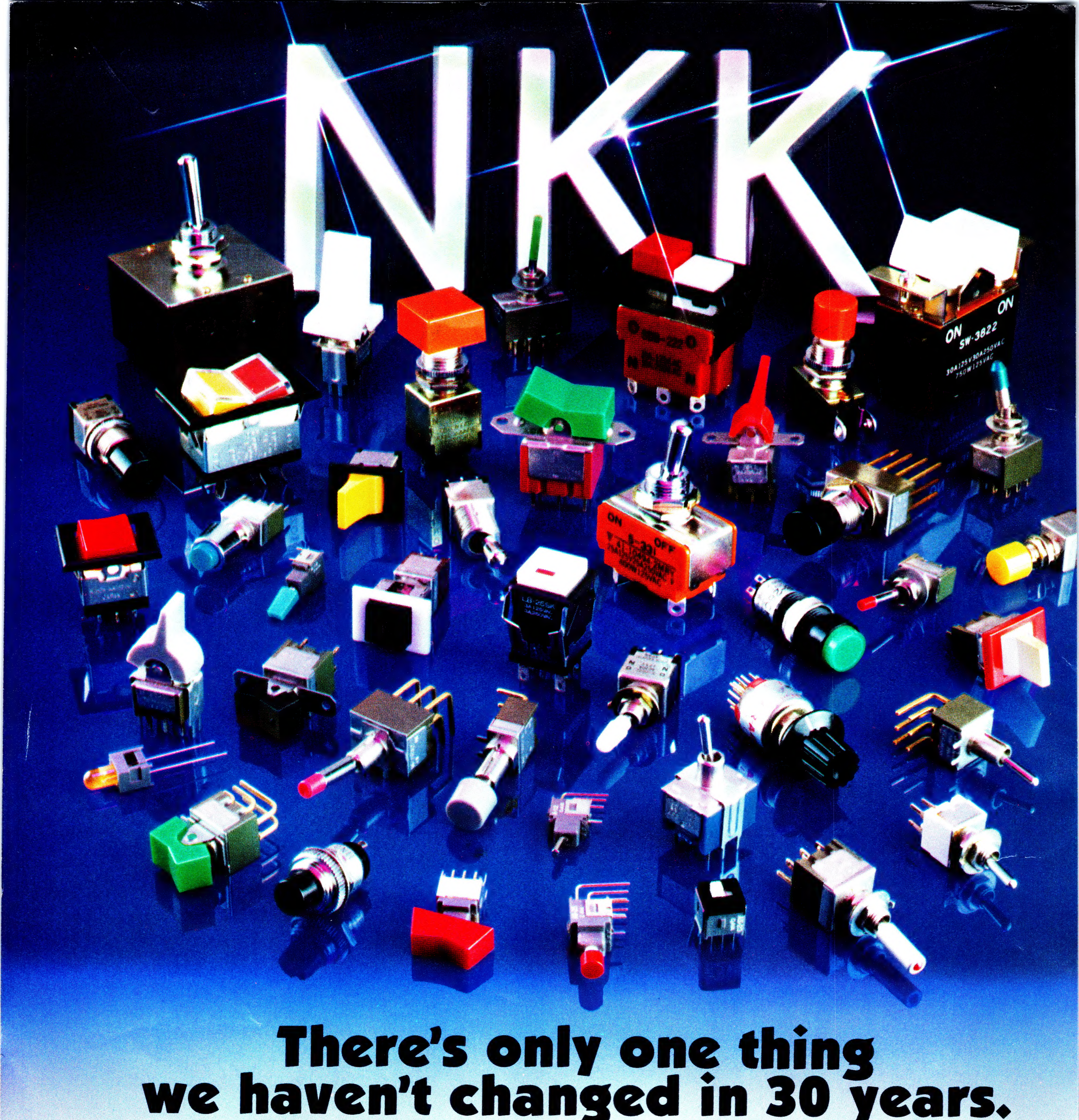
**THE BIG NEWS AT ISSCC: DIGITAL SIGNAL PROCESSORS/50**

**DATA GENERAL'S STRATEGY TO RUN WITH THE LEADERS/56**



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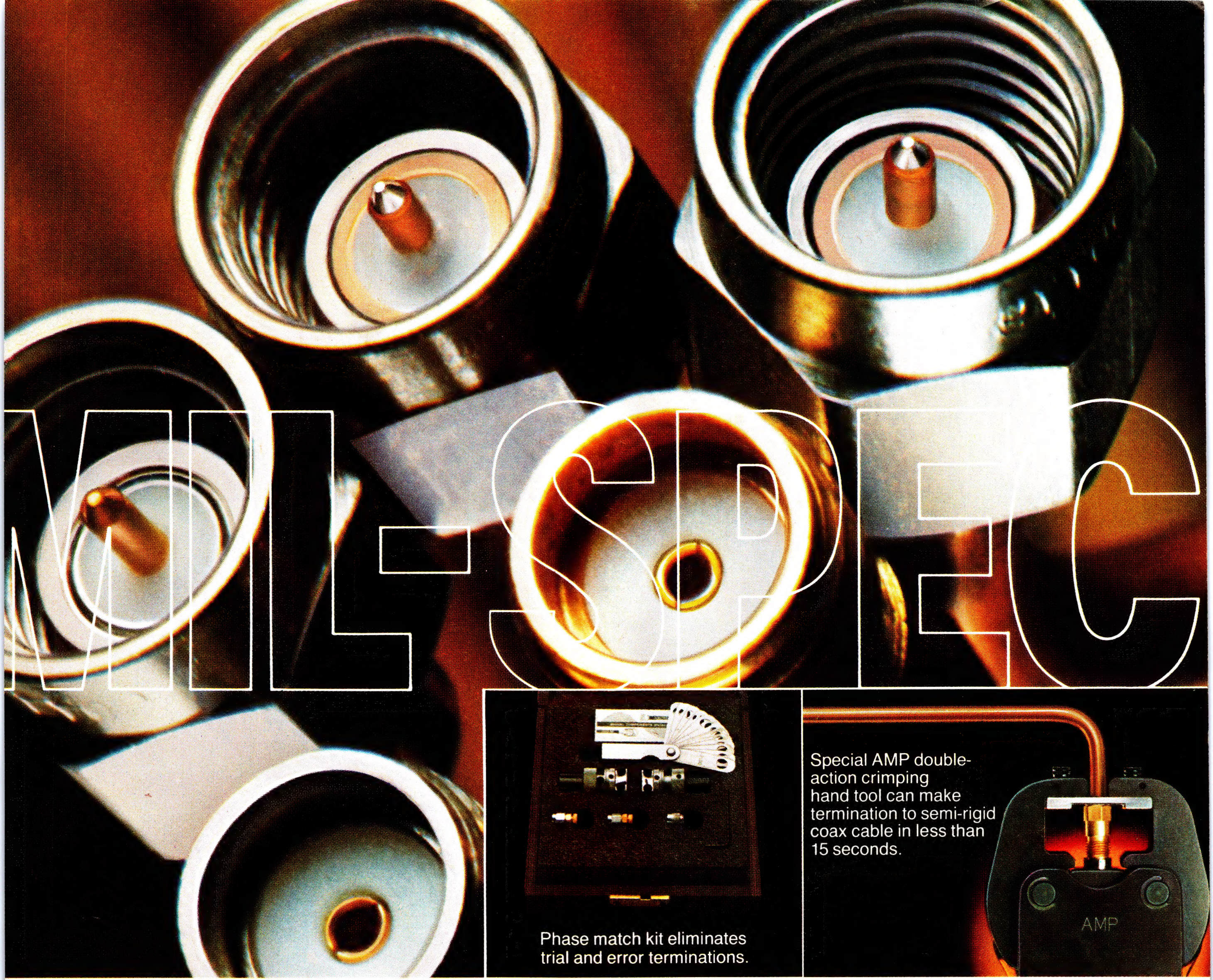

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Stuart B. Flexner, Random House
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DECEMBER 23, 1985 VOLUME 58, NO. 51

# Electronics

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It's the year of the digital signal processor at February's International Solid-State Circuits Conference: scheduled papers will cover 19 designs, including a trio of 32-bit models

## PROBING THE NEWS

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Rough-and-tumble Data General is staking its survival on a move beyond minicomputer "iron." Its all-out thrust into the office market keynotes its drive to become a full-line supplier of information-processing systems. But can it come up with the entire range of products required by its new customers?

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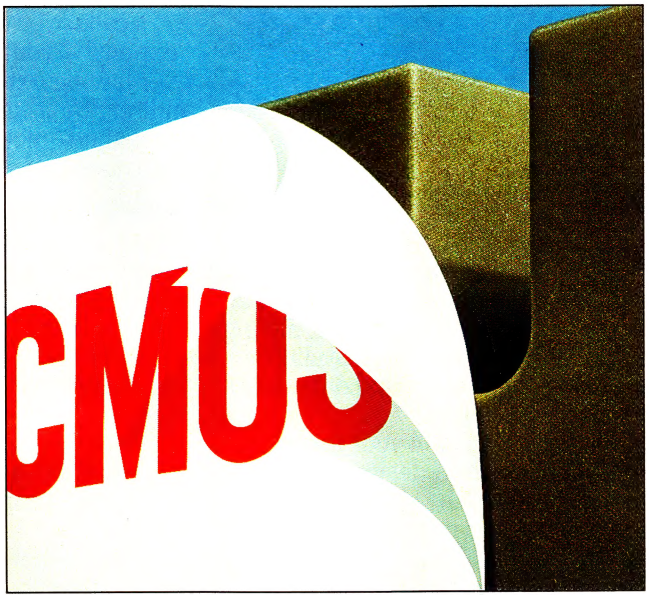

**A bipolar process that's repelling CMOS, 45**
A new fabrication technique could give bipolar processes an extended lease on life. Called Impact X, it uses trench isolation to triple packing density, boost speed and reliability, and halve power consumption. It could hold off the low-power high-density CMOS processes that are threatening to win over many designers of the next generation of digital chips
*Cover illustration by Jeffrey Lynch*

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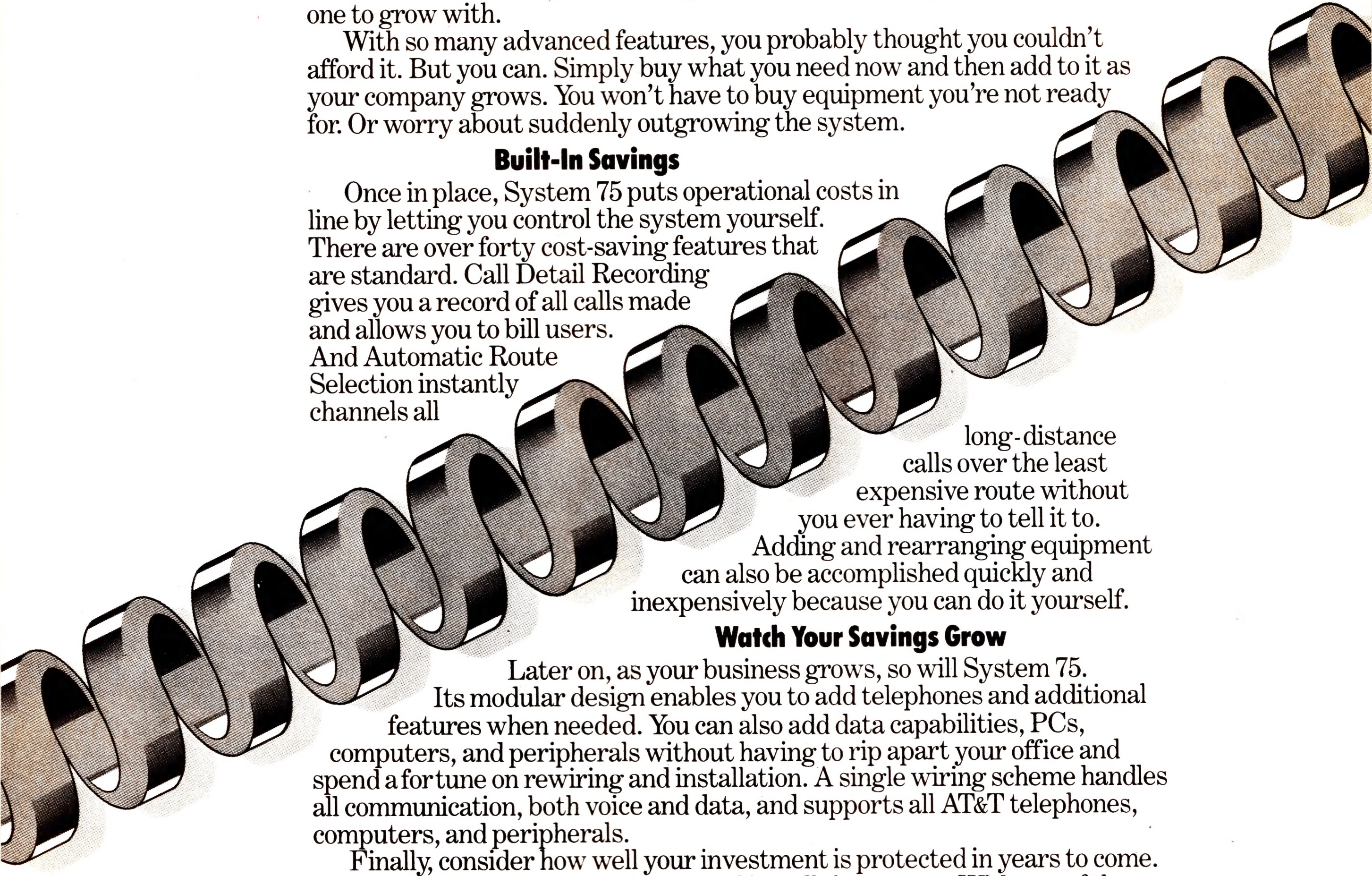

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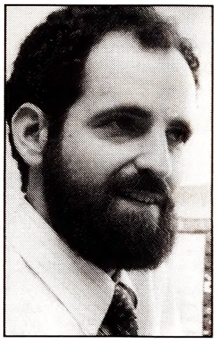
## PUBLISHER'S LETTER

The higher his position in a corporate hierarchy, the more candid the individual can afford to be. Boston bureau manager Craig Rose confirmed that axiom when he was reporting this week's Probing the News on Data General Corp. (p. 56). Craig explains that "interviews with people below a company's top levels are like watching a familiar play but with a new actor. You pretty much know the lines, so therefore your curiosity is mostly over the delivery." This was not the case, however, in Craig's interviews with Data General president Edson de Castro and senior vice president Robert Miller. "You get the party line from people at the top, too, but at least Miller and de Castro would concede that Data General has made mistakes and failed to meet certain expectations."


**HUB.** Rose keeps an eye on New England.

At his meeting with de Castro, Craig noted the contradiction between the executive's reputation as a difficult and autocratic leader and his personal manner. "De Castro was extremely soft-spoken and low-key," says Craig. "But unlike some of the old news clippings, when he was photographed without tie or jacket, this time he put on his jacket for the camera. Maybe that's part of dressing up the image for the Fortune 500 customers the company is courting."

One image in sharp contrast to Data General's intensely bland corporate interior is the office of Herbert Richman, executive vice president. "You travel down what seems like miles of indistinguishable hallways, past rooms with identical cubicles, before you get to his office," says Craig. "Once inside, though, you have to thread your way around the hanging plants to find a place to sit. It was like stumbling into somebody's living room in the middle of a bus station."

In researching the story, Craig was also struck by the way some independent analysts view the company, particularly the wide disparities in their opinions of the way it plans its strategy. For example, he notes, some will give Data General high marks through thick and thin, while others will remain leery of its prospects no matter how well it does.

Who was that man at the IEDM early this month in Washington asking all the questions about papers at next February's ISSCC? It was Bernie Cole, of course. He had flown from his Silicon Valley base to the capital on a twofold mission: to report on the International Electron Devices Meeting and to gather as much advance information as possible about the International Solid-State Circuits Conference.

That he succeeded on both scores is readily apparent from the articles he wrote about these two powerhouse meetings. The IEDM story appeared in *Electronics* Dec. 2, and on p. 50 of this week's issue you will find his preview of the ISSCC.

Laurence Altman

*December 23, 1985 Volume 58, Number 51*
*96,399 copies of this issue printed*

Electronics (ISSN 0883-4989). Published weekly by McGraw-Hill Inc. Founder: James H. McGraw 1860-1948. Publication office: 1221 Avenue of the Americas, N. Y., N. Y. 10020; second class postage paid at New York, New York and additional mailing offices. Postage paid at Montreal, P. Q. Registration Number 9034.

Executive, editorial, circulation, and advertising addresses: Electronics, McGraw-Hill Building, 1221 Avenue of the Americas, New York, N. Y. 10020. Telephone (212) 512-2000. Teletype 12-7960 TWX 710-581-4879. Cable address: MCGRAWHILLNEWYORK.

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The problem has been around for years.

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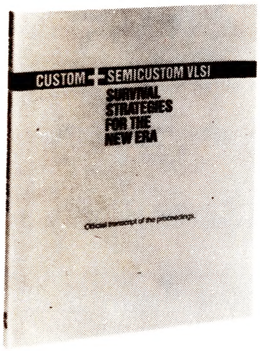
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*LETTERS*

## Boarding buses

**To the editor:** You have published excellent articles on the two major competing buses: the Multibus II and the VMEbus [*Electronics*, Nov. 25, 1985, p. 48; Jan. 14, 1985, p. 30; and March 22, 1984, p. 124]. There have been excellent technical as well as market discussions. They have been of great interest, but there has never been any discussion of the size of boards.

On the one hand, smaller boards result in lower cost for the various options for system builders. On the other hand, smaller boards limit the functionality that can be accommodated on a board. It turns out that both VME boards and Multibus II boards are rather small, significantly more so than Versabus or Hex Unibus boards. One solution to this limit from a local company (DY4 Systems) is to use a deeper VME board (223 by 220 mm) in order to increase functionality. Another solution, which is employed by Sun Microsystems, I believe, is to use VME boards that are three connectors wide. I believe these issues are part of any comparison of the buses.

Also, there is a need for a family of sizes. Though the original Euroboard is either one or two connectors wide, the standard VME board, based on the Eurocard, is always two connectors wide. The concept of multiple widths was popularized by Digital Equipment Corp. in both Unibus (Hex and Quad) as well as in the Q-bus (Quad and Dual). It now appears to have been abandoned.

All these issues of real estate available to designers using each of the buses, as well as an assessment of modern component densities, are worthy of an article.

Marceli Wein
Division of Electrical Engineering
National Research Council Canada
Ottawa, Canada

## Bus war rages on

**To the editor:** We at Gespac are greatly disappointed to see that you omitted the G-64 bus in your otherwise excellent report "Battle of the buses; and the winner is . . ." [*Electronics*, Nov. 25, 1985, p. 48].

You are to be complimented on the overall accuracy of your report on the board market. However, we are surprised that *Electronics*, a well-informed, world-leading authority in the industry, would publish a comprehensive article on the subject that covers all the major buses, secondary buses, and even the "no-bus" buses but fail to mention the G-64 bus.

This discriminating action is even more surprising considering that *Electronics* was one of the first magazines to introduce the bus to the American engineering community last year in an article by Kevin Smith—"Marinello wants to run over IEEE with his G-64 bus," [*ElectronicsWeek*, Dec. 10, 1984, p. 42]. Only for the sake of consistency, you owed it to your readers to keep them informed of our progress.

The international orientation of your magazine should also have made you take into account our outstanding position in the European marketplace where the G-64 bus will represent an $18 million business in 1985. In France alone, the G-64 bus holds a remarkable 10% of the total board market. In North America, our progress has been outstanding, especially considering the little publicity received by the bus. More and more customers are making a similar winning choice by using the G-64 bus over STD, as they do choosing between VME and Multibus II for their more sophisticated applications.

Cosma Pabouctsidis
President
Gespac Inc.
Mesa, Ariz.

□ *The special report concentrated on analyzing those buses that have become IEEE standards or that are recognized as de facto standards, as is the case with PC bus. Although G-64, like the CIMbus backed by National Semiconductor Corp., appears to be an economical and workable solution for 8- and 16-bit buses, it has not become an industry standard. The report focused on 32-bit buses.*

## Reason clarified

**To the editor:** In your article on Inova [*Electronics*, Dec. 2, 1985, p. 57] I was correctly quoted that work on wafer-scale integration should be independent of succeeding generations of random-access memories, but my reason was not made clear: advances in semiconductor technology can be quickly and easily incorporated in wafer-scale integration devices.

Also, mention was made in the article of the failure of Trilogy's wafer-scale project, but it should be emphasized that the Inova effort is considerably less ambitious than Trilogy's six-layer-interconnection, 2,000-pin, kilowatt wafers and thus is much more likely to succeed technically.

Gilman D. Chesley
Wafer Virtual Memory
Los Altos, Calif.

# Ethernet Test:

What is the traffic loading of your Ethernet?

Who is involved in data exchange?

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How long are the data packets?

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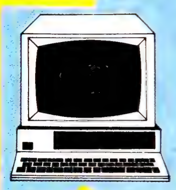

**Monitor mode**

- Disassembled display of data traffic
- Selective collection (e. g. user addresses only)
- Automatic generation and testing of CRC word
- Measurement of data transfer timing
- Measurement of traffic loading by means of histogram display

**Network simulation**

- Data terminal testing without network

Ethernet

Transceiver

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**Generator mode**

- Sending of test patterns
- Generation of collisions for checking network behaviour
- Simultaneous analyzer and generator operation

How often do collisions occur?

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Circle 80 on reader service card

**SIEMENS**

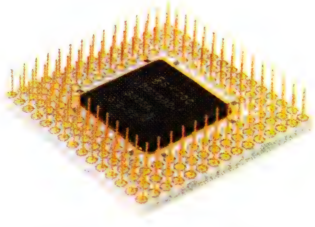
## A jump ahead in ECL gate arrays. The world's fastest manage 0.2 ns gate propagation delay. They come from Siemens.

ECL gate arrays are what hi-tech's all about. To develop them you need to be broad-based. Which is what Siemens is: with experts, know-how and resources. Plus the synergetic advantage of the systems experience brought in by all the company's different divisions.

Thus we're able to develop and manufacture products that set standards in technology, in quality, in reliability.

All guaranteed by 26,000 employees and the thousands of millions that go into R & D. The confidence innumerable customers place in our innovative products is well-founded.

**Everything it takes in electronics. Siemens.**



2500 gate functions and 0.35 ns gate propagation delay on a chip area of 75 mm$^2$ is what we do today. And we're already working on gate arrays with 9000 gate functions and 0.2 ns propagation delay in OXIS III technology on 130 mm$^2$ area. What we're envisaging?

20,000 gates and 0.05 ns on 300 mm$^2$ with conductor path spacings of 1 µm and more than four metallization layers in OXIS IV/V technology.

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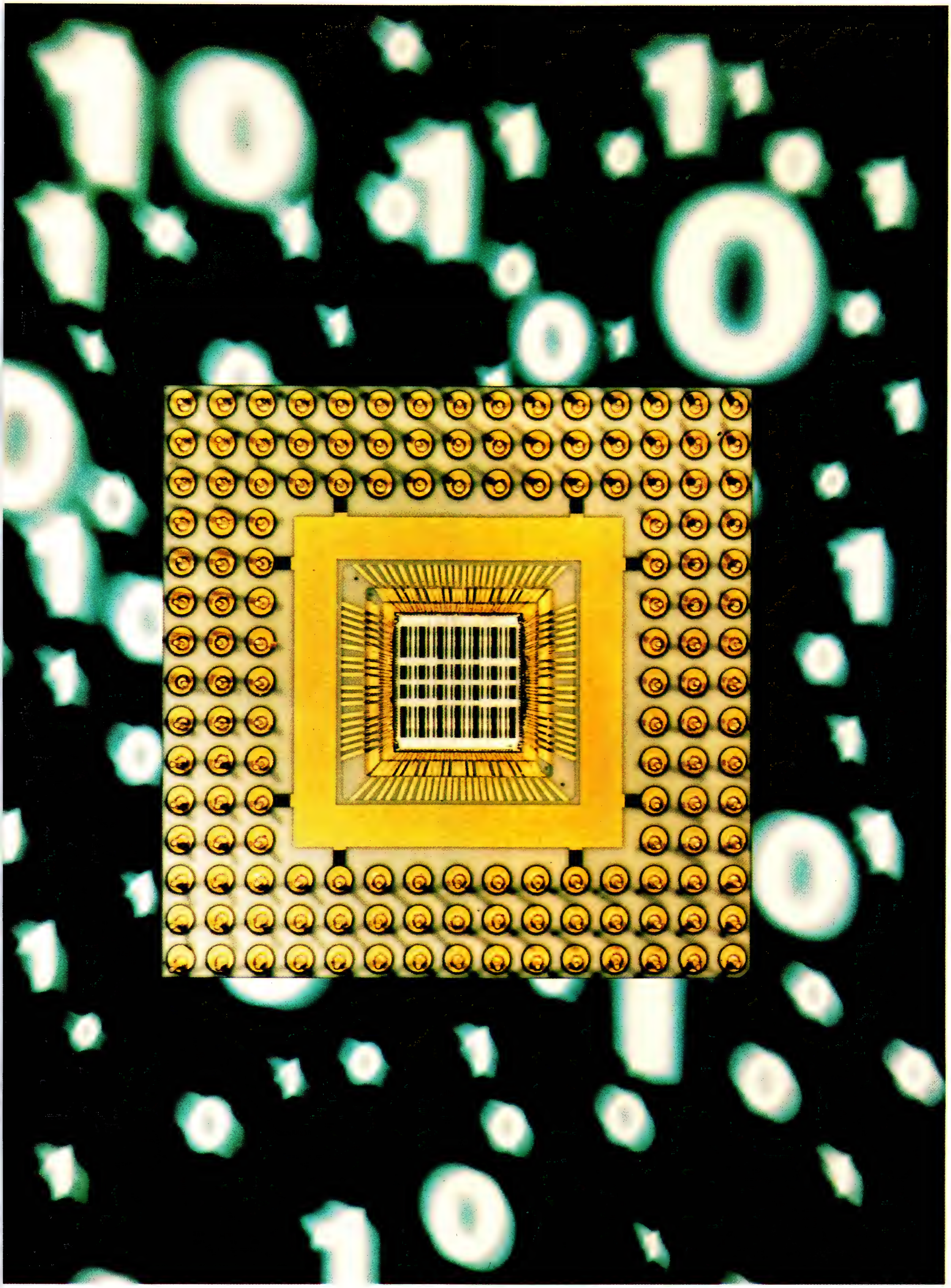
Mainframes are getting more powerful all the time. We use the synergetic effect of in-house applications. That's why we build the fastest gate arrays in the world. The quality and reliability of our components have put us among the leaders in Europe.



Gate arrays from Siemens are in a hi-tech class of their own. With path spacings of 1 µm and 9000 gate functions combined on a 130 mm$^2$ chip. Siemens has shown and gone new ways in the development of gate arrays.

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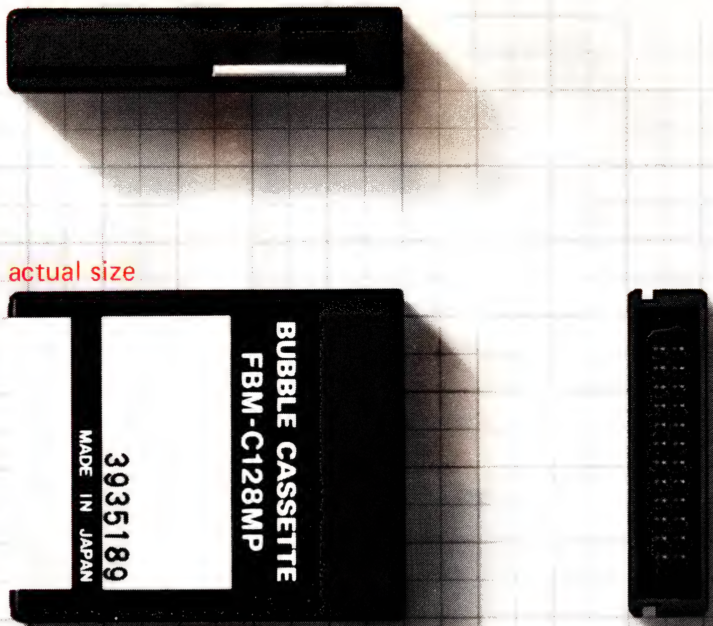
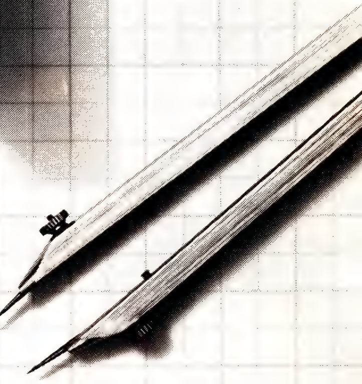
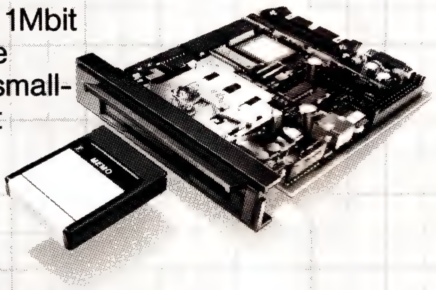
NEW





# Smallest in size, bigger in memory.

## *Fujitsu introduces world's smallest 1M bit compact bubble cassette.*



Fujitsu's unique 1Mbit compact bubble cassette is the smallest and thinnest memory of its kind in the world. It's also lightweight, easy to carry, dust-proof, shock-resistant and maintenance-free with no mechanical parts, so it's ideal for use in hand-held terminals of every kind. And it features a fast access time of 12.8ms and 8-bit parallel interface. For full details on this amazingly compact, high-performance memory system, contact the address below.

**Major Specifications**

| | |
|---|---|
| Compact cassette | FBM-C128MP |
| Holder unit | FBM-U550GA |
| Memory capacity (user area) | |
| Data area | 128K bytes (64 bytes/page x 2048 pages) |
| Sub-pages | 192 bytes |
| Mean access time | 12.8ms (2.6ms with SEEK command) |
| Interface | 8-bit parallel (DMA capability) |
| Transfer rate | 100K bits per second (max) |
| Transfer method | 64 bytes block transfer |
| Dimensions | |
| FBM-C128MP | 52(D) x 43(W) x 11(H) mm |
| FBM-U550GA | 156(D) x 125(W) x 25(H) mm |

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- Siemens Readies Commercial ISDN
- Japanese Chemical Firm Moves from Soap to Floppies
- Italian Firm Seeks Allies to Crack U.S.
- Japan Pursues Role in Space
- Bellman Switches on Italtel for Expansion
- Robots get Smart in Japan
- ITT Invests in European Units Crack U.S.

**February**

- Europe's Esprit Finally Sets Sail
- LSI Logic Counts on Sandfort to make its Mark in Europe
- Upstart Vendor Makes Waves in Japan's Robot Market
- NEC Fashions New Fab Process
- Olivetti's Viti Directs ET Designs that Marry Bus & Art
- German Startup's Success Surprises Europeans
- Britons Seek Tolerant Chips
- OBI Rains on IBM's Parade
- Mega's Friedrich Aims to Cut Asian Lead in Memories

**March**

- British GaAs Chips Go to Market
- NEC's CPU Leapfrogs IBM
- Hitachi CPU Challenges IBM
- France's Lansat Rival Set for Fall Launch
- Olivetti Stakes Claim in Video Typewriters
- Italian VLSI Chip has the Right Accent
- Koreans Try for VCR Replay
- Germans Push X-ray Exposure
- There's Life in Resistors, German Company Finds
- UK Beats a Path for Europe's Race

**April**

- German System Meets New ICAO Standard
- West Germans Squabble Over Choice of IFF
- Britain Promotes Open Architecture
- US Makes Progress in Japan Telecom Talks
- Japan's Lead in Optical Disks: It's Part of the System
- Daisenberger Guides US Firms through Red Tape
- Asia: It's No Longer Just Japan That Threatens US Markets
- Malaysia: Top Shipper of Discretes
- Indonesia: Domestic Sales are the Lure

**May**

- Thomson's VCR System Clears Up Doubts
- ICL Banks on Networks and Japanese Chips
- Min Blazes Bright Path for Korea's Gold Star
- Asia: The Four Dragons Rush to Play Catch-up Game
- Singapore Casts Lot with Software
- Philips' Eurom Chip Finally Debuts
- Sagging Prices Sting Japanese Producers
- British Telecom Spreads Its Wings with Mitel
- South Korean IC Maker Seeks World Markets

**June**

- Plessey Switches Off Flash ADC, Saves Power
- Sony Campaigns Hard for BMM Camcorders
- Japanese Quit on IBM Software, Turn to UNIX
- Apple Tries Again to Blast Off in Japan
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# HALLEY'S COMET SPACE ENCOUNTER SET FOR MARCH.

The ultimate space encounter is about to begin. Halley's comet, making a brilliant comeback after 76 years, will soon provide scientists with a once-in-a-lifetime opportunity to shed new light on the origins of the solar system.

As part of a global research effort, Japan's Institute of Space and Astronautical Science, the Ministry of Education, has sent out a welcoming mission of twin interplanetary probes—SAKIGAKE (Pioneer) and SUISEI (Comet)—which are due to intercept Halley's comet in March '86 soon after its closest approach to the sun.

The two deep space explorers will obtain invaluable new data on solar wind—waves of plasma emitted by the sun—and its effect on the comet. Simultaneously, SUISEI will reveal the 3-dimensional structure of the hydrogen cloud surrounding the coma with an ultraviolet TV camera and beam the image data to the earth up to 170 million km away.

For its part, NEC's involvement in these space probes included system design, system integration and the manufacture of major subsystems for telemetry and command, the antenna, power, data processing, attitude and orbit control.

With 20 years of experience in space development NEC has contributed, as a prime contractor or system integrator, to 20 of the 32 satellites placed in space by Japan since 1970.

*Photos courtesy of the Institute of Space and Astronautical Science, the Ministry of Education, Japan.*

C&C
Computers and Communications

# NUMBER 134

## KUWAIT CHOOSES NEC CELLULAR MOBILE TELEPHONE.

NEC will install an integrated cellular mobile telephone system in Kuwait by the 3rd quarter of 1986, paving the way for truly high-grade services nationwide.

NEC's total access communications system featuring 25kHz frequency spacing in the 900MHz band will initially serve up to 25,000 subscribers, and can be expanded to accommodate up to 100,000 subscribers.

Awarded by the Mobile Telephone Systems Company (MTSC) of Kuwait, the full turn-key contract calls for NEC to manufacture and install all key equipment, including an advanced digital switching system plus radio equipment for 21 base stations and 15,000 mobile telephones. MTSC is a shareholding company, 49% Government and 51% public, established to run all mobile communications in the State of Kuwait.

Moreover, NEC will also provide the latest microwave radio and fiber optic links to interconnect the central switching system and base radio equipment, and a medium-scale computer for message accounting and communications traffic control.

This massive project is well under way, drawing upon the integrated computer and communications technology of NEC and expertise of all concerned companies.

Upon completion, the new system will provide sophisticated services such as "Call Transfer", "Call in Absence" and "Privacy".

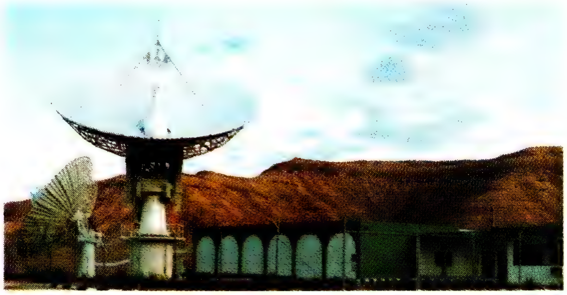
## NEW TTC & M EARTH STATIONS FOR ARABSAT.

An advanced NEC satellite control network is now providing complete tracking, telemetry, control and monitoring (TTC & M) services for the Arab Satellite Communications Organization (ARABSAT) which is comprised of 22 Arab League countries.

The ARABSAT Satellite Control Network analyzes and processes satellite telemetry and tracking data, and commands and monitors operating conditions of the Arab world's first series of communications satellites—the ARABSAT-1A and ARABSAT-1B.

This integrated control system consists of a primary earth station at Riyadh, Saudi Arabia, and a secondary station at Tunis, Tunisia. All necessary equipment including computer hardware and software systems, were developed and installed by NEC on a turn-key basis to assure optimum system performance and long-term reliability.

NEC's contribution to the growing ARABSAT network also includes the completion of three earth stations—one each in Jordan, Bahrain and Tunisia—and it is now manufacturing 7 more for use in other Arab countries.



The ARABSAT system can accommodate 8,000 simultaneous telephone circuits, seven television channels and a community television channel for isolated rural areas. It can also provide telex and data transmission services, and other specialized services.

## 4-BIT MICROS RIVAL 8-BIT POWER.

The new NEC 75000 Series of 4-bit CMOS single-chip microcomputers is the first to bring VLSI expertise and advanced architecture to the 4-bit realm for results that rival 8-bit performance.

The 75000 Series combines added on-chip memory up to 16k-byte ROM/4k-nibble RAM and higher speed—less than 1$\mu$s cycle time at 4MHz. Other high-end features include powerful on-chip hardware, outstanding expandability and an enhanced instruction set.

The 75000 Series comes with a full kit of hardware/software development tools and it also inherits the software of our industry standard 7500 Series through easy conversion.

The first four members of the 75000 family are currently available —the $\mu$PD75104 and $\mu$PD75106 high-performance general purpose micros, the $\mu$PD75P108, an EPROM version, and the $\mu$PD75206, which incorporates a VF controller/driver.

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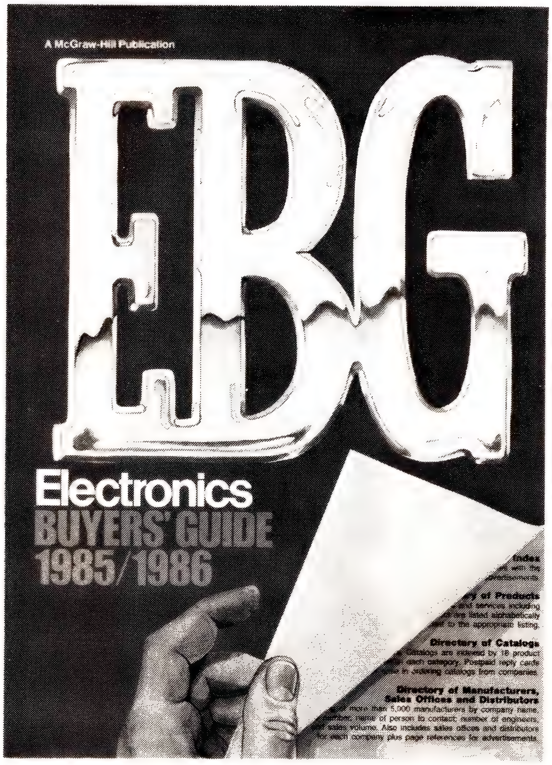

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# TECHNOLOGY NEWSLETTER

## JOSEPHSON-JUNCTION CHIP PROVIDES MORE ACCURATE VOLTAGE STANDARD

Voltages can be calibrated to within a few parts in $10^{10}$ using a new standard based on a Josephson-junction chip designed by West Germany's Physical-Technical Standards Institute in Braunschweig. Standard cells are capable of a few parts in $10^8$. The initial measurements, the most precise yet, were made at room temperature; in a liquid-helium environment, it should be possible to improve accuracy 1,000 times, to within a few parts in a total of $10^{13}$. The chip, the heart of the standards apparatus, integrates 1,400 Josephson tunnel elements and is exposed to a 70-GHz microwave frequency. From two fixed electrodes, a voltage from 0.1 to 1.3 V, whose stability depends solely on the microwave frequency, can be picked off. ☐

## SINGLE-CHIP PAGER OPERATES ON SSB OR FM, GOES TO WAR

The zero intermediate-frequency technology developed by STC Telecommunications Laboratories and used in STC plc's single-chip radio pager will soon be turning up on the battlefield. The lab in Harlow, England, recently won a Ministry of Defense contract to use the technology in a universal manpack that can communicate with incompatible communications systems used by North Atlantic Treaty Organization countries. By teaming their zero i-f technology with high-speed digital signal processing, STL researchers have demonstrated a prototype transceiver that emulates different radio modes—both in use and planned—such as single-sideband and frequency-modulation. The contract calls for STC to produce a very large-scale IC version and is part of the ministry's Very High-Performance Integrated-Circuit Application Demonstrator Initiative. STC has won three contracts worth $25 million under the project, funded equally by the ministry and participating companies. ☐

## EXPERT SYSTEM MOVES INTO MILITARY COCKPIT

Artificial intelligence will move into the fighter cockpit in a program gearing up at the Air Force's Wright Aeronautical Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio. Proposals are due Jan. 10 for the Threat Expert Analysis System, an AI system that will warn pilots of enemy threats and recommend possible responses. Designed to increase pilots' chances of surviving combat missions, it could succeed today's radar-warning receivers. A major part of its knowledge base will likely be electronic intelligence information on Soviet radar parameters. An initial study contract will be let in April, and prototype software for the lab demonstration version will be ready in early 1987. ☐

## FLORIDA STARTUP BEATS ITT TO MARKET WITH PARALLEL-PROCESSOR BOARD

A Boca Raton, Fla., startup plans to begin selling a parallel-processor board for IBM Corp.'s Personal Computer in the first quarter of 1986. If it meets its schedule, Compupix Technology Inc. will beat hardware heavyweights such as ITT Corp. and parallel-processing specialists such as Ncube Corp. [*Electronics,* Nov. 18, 1985, p. 23]. To steal its march, the company designed its add-on around NCR Corp.'s Geometric Arithmetic Parallel Processor chip, which houses a CMOS array of 72 processors. Compupix's board can add up to 288 processors to an IBM PC. The board will come in two configurations: one with two chips for a total of 144 processors sells for under $5,000; the other, with four chips for 288 processors, costs $6,000. Like ITT's board, Compupix's uses a single-instruction multiple-data-path architecture. Operating at up to a 10-MHz clock speed, the board can perform 20.8 billion floating-point operations/s and will run on operating systems compatible with AT&T Bell Laboratories' Unix. ☐

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# ELECTRONICS NEWSLETTER

## IBM JAPAN AND NTT FORM JOINT VENTURE IN COMMUNICATIONS

IBM Japan Ltd. and Nippon Telegraph & Telephone Corp. have teamed up for a venture in advanced information-communications systems aimed at opening new doors for both partners: for IBM, a better crack at the Japanese market for work stations and small computers, and for NTT, entry to the worldwide market for value-added networks. Their new company, Nippon Information & Communications Corp., will begin in January to develop advanced information-communication services and network systems, including an overseas gateway using IBM hardware, software, and Systems Network Architecture. According to government policy, NTT will have to convert its extensive data-communications and -processing network to a separate, private company. Tsuyoshi Iwashita, the joint venture's president, says he expects billings of $25 million in the second year. The company also expects to operate at a loss for its first three years, but turn a profit in the fourth year and recoup cumulative losses during the fifth. □

## AMERITECH TO POUR $1 BILLION INTO FIBER OPTICS AND DIGITAL SWITCHES

The regional Bell operating companies will continue to pour megabucks into the installation of fiber-optic systems and digital switching and transmission lines next year as they fight to dissuade other phone-service providers from bypassing the BOCs' systems. The latest effort came last week, when Ameritech (American Information Technologies Corp.) said that nearly half of its $2 billion capital-spending budget next year will go toward such systems. Ameritech, based in Chicago, plans to double the number of digital switches in its network to a total of 225 by the end of 1986. It will also increase the miles of fiber-optic cable within its five-state system to 120,000, up 56% from the 77,000 miles in place today. Next year's investments will bring Ameritech's total capital spending to some $5.7 billion over the three years from 1984 through 1986. About $2.5 billion of that total is earmarked for fiber and digital gear. □

## WEST GERMANS SUPPORT SIEMENS-PHILIPS MEGA PROJECT

The West German government has agreed to support the Siemens-Philips Mega project to the tune of $130 million. The Dutch government has indicated it will dish out about half that much—$65 million. Under the Mega project, which calls for a total of $560 million of research and development money [*Electronics*, Oct. 29, 1984, p. 28], Siemens AG of Munich will aim at 1- and 4-Mb dynamic random-access memories, to come out as samples in 1986 and 1988, respectively. Dutch Philips is shooting for a 1-Mb static RAM, also to be sampled in 1988. □

## FORD AEROSPACE SELLS SATELLITE IN JAPAN

Competition is building in the Japanese communications-satellite business. Ford Aerospace and Communications Co. has nailed down a contract—reportedly for $255 million—with Space Communications Corp. of Tokyo for the delivery of a 1.3-ton communications satellite to be launched in February 1988. That will put SCC a couple of months behind its rival, Japan Communications Satellite Corp., also of Tokyo. JCS earlier announced a buy of two satellites from Hughes Communications Corp., which has a 30% interest in the Japanese company. The first satellite will be launched in December 1987 and the second launch in February 1988. JCS reportedly has 30 Japanese customers lined up for the first 32-transponder satellite, and is negotiating with Nippon Telegraph & Telephone Corp., which is interested in leasing an additional 10 transponders. □

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Left to right, Fred Molinari, President

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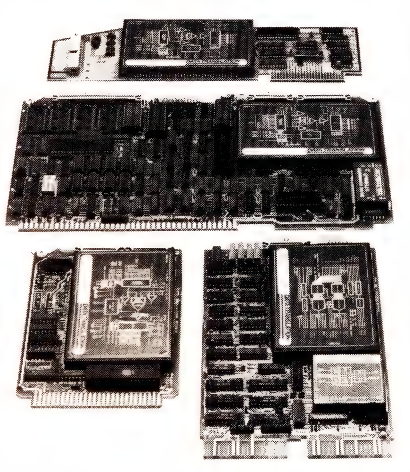

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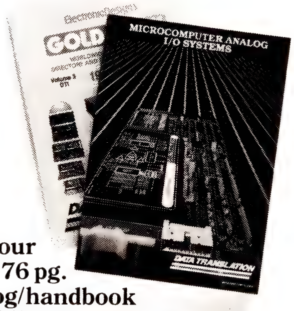
| LSI-11 | X | X | X | X |
| IBM PC | X | X | X | X |
| APPLE II | X | | | |



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Circle 18 on reader service card

*DECEMBER 23, 1985*

# PRODUCTS NEWSLETTER

## BURROUGHS WORK STATION INCREASES CLUSTER CAPABILITY

The latest Burroughs Corp. work station could fit the bill for users who need more capability in a work station-cluster controller than the Detroit company's current B 25 system provides. The new B 28 and B 28-MCP are designed primarily for use as master work stations with the ability to support up to 11 clustered work stations. That goes beyond the current B 25, which can cluster five stations. The B 28 is powered by Intel Corp.'s 80286 microprocessor and costs $5,130 for an entry-level system equipped with 1 megabyte of memory without disk storage. The B 28-MCP adds an 80287 math coprocessor and starts at $6,130. Both versions are scheduled for availability in February. ☐

## ZILOG WILL FINALLY START SHIPPING 32-BIT PROCESSOR IN FIRST QUARTER

Zilog Inc. will begin accepting orders on Jan. 1 for its long-awaited Z80,000 32-bit microprocessor. The Campbell, Calif., company is targeting military applications, graphics processing, and digital signal processing as its key markets, leaving the general computing market to such suppliers as Intel and Motorola. Surprisingly, the clock rate on the 2-$\mu$m n-MOS Z80,000 is only 10 MHz, but Zilog says that its advanced features—such as six-stage pipelining and on-chip data and instruction caches—will give a throughput comparable to 12- or 14-MHz parts. Price is $365 in single units, and delivery will begin in the first quarter. Scheduling for a CMOS version may be forthcoming when Zilog announces its CMOS plans in January. ☐

## NATIONAL SEMICONDUCTOR CHIP EASES DESIGN OF MICROSYSTEMS

Working with 1-Mb DRAMs and fast microprocessors will be a snap thanks to two 1-Mb DRAM controller/drivers from National Semiconductor Corp. The DP8428 and DP8429 integrate on-board refresh counters, multiplexing logic and bank-address latches, row-address-strobe bank-decoding logic, and control and timing logic for sequencing access and refreshing tasks. They directly drive 8 megabytes of memory and work with central processing units running at 10 MHz or faster without wait states. The chips integrate a precise delay line that allows for a typical row-address-strobe to column-address-strobe delay of 40 ns. Samples will be available in March for $45 each in lots of 100 pieces. ☐

## INTERNATIONAL RECTIFIER TO BRING OUT SURFACE-MOUNTABLE MOS FETs

International Rectifier Corp. will be making available surface-mountable versions of two of its power MOS FETs, the IRF1Z0 and IRF1Z3 Hexfets. The El Segundo, Calif., company's Hexfets are targeted for use in mobile phones, hand-held calculators, and laptop computers. Both the 100-V IRF1Z0 and 60-V IRF1Z3 will be housed in SOT-89 packages. In lots of 1,000 pieces, the Hexfets will sell for 71¢ each, or about 24¢ more than 100-V versions in the standard four-pin DIPs. Delivery will begin in January. ☐

## TANDON'S PLUG-IN WINCHESTER HAS HIGHEST CAPACITY YET

Tandon Corp. is packing the highest capacity yet—and charging the lowest price—in a plug-in Winchester-disk-drive card that installs in any IBM Corp. Personal Computer or PC/XT. The Diskard 21 has 21.3 megabytes of storage capacity and sells for about $995, which is $100 less than its nearest competitor, Mountain Computer Corp.'s 20-megabyte card. Diskard 21 uses only a single slot and is compatible with PC-DOS and MS-DOS. It is available now from the Chatsworth, Calif., company. ☐

NEWS
DECEMBER 23, 1985
Electronics

# SIMPLE WAFER FUSION BUILDS BETTER POWER CHIPS

## ATOMIC BOND IS FORMED TO MAKE DEEP JUNCTION, ISOLATION LAYER

**KAWASAKI, JAPAN**

Engineers at Toshiba Corp. have developed a method to fabricate the critical p-n junction in a power device by bonding together separate p- and n-type silicon wafers. Their stunningly simple atomic-bonding technique replaces the days-long process that builds the thick diffused and epitaxial-growth structure needed for high-voltage operation.

The process makes power devices that perform better, achieving breakdown voltage and operating frequencies that are higher than those made by conventional technologies, according to Takeshi Ozeki, manager of the Electron Devices Laboratory at Toshiba's Research and Development Center in Kawasaki [*Electronics*, Dec. 16, 1985, p. 15].

Greater power-handling capability for a given size chip is a direct result of operation at higher voltages. The process also makes it easy to build a dielectric layer that enables chip designers to put low-power logic and high-power functions on the same chip. The company expects to announce the first commercial devices made with atomic wafer bonding sometime next year.

**PREVIOUSLY UNDEVELOPED.** The process had gone undeveloped because useful results appeared so unlikely to semiconductor specialists, Ozeki believes. Wafers are first processed to the desired p- or n-type surface layer without destroying their mirror polish. They then undergo what Ozeki describes as hydrophilic water processing to ensure complete wetting and formation of a film of activated hydroxyl radicals on the surface after drying. Process steps include organic-solvent wash, acid wash, and deionized water rinse.

In the atomic-bonding process, dried wafers are mated and heated to 1,000°C for about 30 minutes in a nitrogen ambient. Initially, hydrogen bonds are formed between the hydroxyl radicals on the two surfaces. As the temperature increases, a dehydration condensation reaction occurs. A single oxygen bond replaces two hydrogen bonds, and water diffuses out of the interface. As the processing continues, many of the oxygen bonds are replaced by silicon bonds, and oxygen atoms diffuse into the bulk silicon.

Mechanical tests show that the fracture strength of the bond equals that of bulk silicon. Transmission scanning-electron-beam microscope photos show a continuous crystalline structure has replaced the interface of the two wafers. Both results are strong indications of atomic bonding. However, in the photos, a band perhaps 2 nm thick at the junction shows a slightly different density, perhaps because of slightly increased defect density.

**EARLY RESULTS.** Toshiba researchers have not completely evaluated the junctions fabricated this way. They have discovered, though, that the junctions have properties superior to those of junctions made by conventional technology in bipolar MOS FETs. This suggests there are few deep-level traps at the junction and that the junctions are more abrupt. Junctions made deep in the structure of conventional high-voltage devices lose abruptness because diffusion occurs during high-temperature processing for subsequent layers.

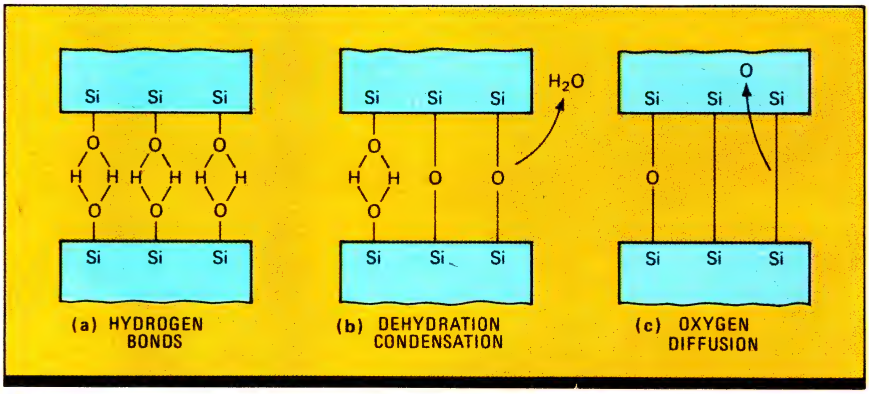
The process has not yet been used to fabricate thyristors. These devices have much more stringent requirements for minority-carrier lifetime than do bipolar MOS FETs, a type of vertical power MOS FET in which injection from the substrate provides conductivity modulation of the long vertical drain region and reduces its voltage drop. The drain current in the MOS-FET part of the device is the base current of its bipolar part—a vertical pnp transistor. Toshiba usually fabricates such devices on a $p^+$ substrate. An n-layer is formed on the substrate surface by diffusion to control bipolar transistor injection, and an epitaxial $n^-$ layer, which must be very thick to withstand the applied voltage, is grown on top.

There is a limit to how thickly the epitaxial layer can be grown, and interfaces between the n and $p^+$ layers and the n and $n^-$ layers tend to become less sharp because of diffusion during the long high-temperature processing. Nonuniformity over the area of the wafer can also be a problem.

But Toshiba forms the n layer by diffusion into an $n^-$ substrate, then uses atomic bonding to form the junction between the n layer and $p^+$ substrate. Grinding and lapping remove excess thickness of the n layer, and the channel, source, and gate structures are fabricated conventionally.

Fabrication is faster, and devices have higher breakdown voltage and retain their breakdown capabilities at higher frequencies. Operation at higher frequencies permits pulse-width modulation inverters to synthesize power-frequency sine waves with shorter pulses, whose fundamental frequencies are above the range of human hearing. That helps to prevent the generation of unpleasant noise in the motors they drive.

The process is also useful for fabricating large power transistors with die-


(a) HYDROGEN BONDS
(b) DEHYDRATION CONDENSATION
(c) OXYGEN DIFFUSION

**BAKED OUT.** In 1,000°C heat, hydroxyl radicals clinging to the surface of two wafers form hydrogen bonds (a). Then water molecules escape (b), and oxygen diffuses into the silicon (c).

lectrically isolated logic circuits. This is done by bonding silicon dioxide films grown on the surfaces of two wafers. The silicon on one side of the $SiO_2$ layer embedded between the two wafers is then ground and lapped to a thickness just sufficient to fabricate the active devices. Moats are etched into this silicon down to the $SiO_2$ layer and filled in with more $SiO_2$ to form islands on which isolated circuits or devices can be fabricated. The silicon on the other side of the layer becomes a supporting substrate that features the high heat conductivity of single-crystal silicon.

Conventionally, these devices are fabricated by etching V grooves in a wafer and then forming an $SiO_2$ film on the surface. Polycrystalline silicon is deposited on top of the $SiO_2$ layer deeply enough to become a wafer substrate. Then most of the original wafer is removed by grinding it down past the bottoms of the Vs to produce a number of dielectrically isolated single-crystal islands on the polysilicon substrate. But such devices cannot dissipate power as readily because the thermal conductivity of polysilicon is much lower than that of single-crystal silicon.–*Charles L. Cohen*

***COMPONENTS***

# CUSTOM POWER DEVICES SHOW SURPRISING GROWTH

**LOS ANGELES**

As the battle for volume orders of standard power chips rages undiminished, some suppliers are quietly making sorties into a fast-developing niche market: custom circuits.

Buyers are turning to them—in both hybrids and monolithic chips—for two principal reasons, both triggered by increasingly sophisticated equipment. First, off-the-shelf power devices no longer fill the bill. Second, only the most sophisticated end users can handle the design chores needed to incorporate standard parts efficiently into new equipment without help. These trends have been building since the early 1980s, but the move to custom power MOS FET circuits has picked up speed in recent months, surprising even the suppliers themselves.

"No question, there's a tremendous groundswell," observes David Cooper, director of MOS Power Business at Siliconix Inc., Santa Clara, Calif. The company's custom work deals largely with high-performance military applications, which carry high margins, but Siliconix expects to move into the commercial market soon.

Other power-chip makers, some even farther along with customized industrial products, include International Rectifier, the Power Transistors Division of Motorola's Semiconductor Products Sector, and General Electric's Power Electronics Semiconductor Department.

The first company to set up a separate unit for this business was International Rectifier Corp., El Segundo, Calif., which early this year moved to produce custom hybrids. "People who needed more than the standards came to us," says Howard M. Abramowitz, executive director of custom products business management. The company immediately saw potential beyond simply doing a custom design and packaging job, according to Abramowitz. Instead, if the power hybrid looked as if it could command a broader market, the plan was to offer a price break in return for the buyer's agreement to allow the custom unit to become a standard product itself.

International Rectifier has followed this practice with five hybrids so far, now part of a growing standard power hybrid family. Abramowitz says all have drastically cut the parts count from a comparable discrete implementation, and are designed into customer equipment. One example is a motor-driver circuit, previously requiring 80 MOS FETs and 80 diodes, but now reduced to 10 components. A stepper-motor driver using MOS FETs is nearly complete.

The Motorola Inc. division in Phoenix, Ariz., follows a similar path, with its monolithic logic-to-power switch, the MPC1500, which switches power loads. Designed for an automotive customer, the circuit "no doubt will be a mainstream product," asserts Jack Takesuye, product planner for Smart-power and power MOS FETs. Motorola builds the MPC1500 in n-MOS, for the power output, with a CMOS process for the logic input.

GE Co. unveiled its power-chip plans at Wescon in San Francisco last month, announcing an application-specific semicustom design approach where basic circuit elements are shared. "Since each application is different, GE will not offer a standard line of smart power products," explains J. Larry Smart, general manager of the GE Power Electronics Semiconductor Department, Syracuse, N.Y. Once developed, however, the devices could then be offered widely.

The first product, developed for GE's motor operations, is a control circuit for fractional-horsepower electric motors. Rated at 500 V with the potential of switching up to 10 A in less than 1 $\mu$s, it employs a BiMOS process.

**CLEARING UP.** Although the custom power business is just beginning to sort itself out, several things are already becoming clear. "Ultimately, it is a price-driven game," points out semiconductor-market analyst William Groves of In-Stat Inc., Scottsdale, Ariz. And the economics of custom monolithic devices dictate high enough costs that "it's going to be a hybrid market for a long time," because hybrids employ clever packaging and existing ICs.

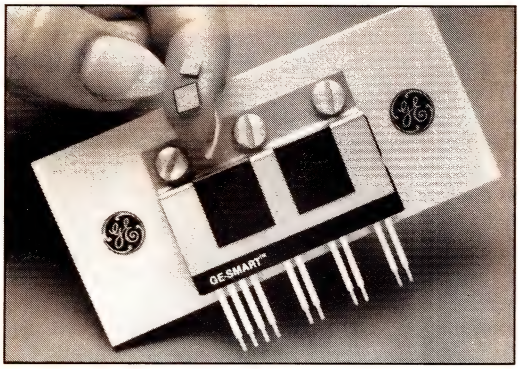
In Groves' view, the custom power development most closely parallels what happened after TTL circuits were introduced around 1969. "People found they weren't the answer by themselves, but needed all kinds of glue circuitry to make them go."

International Rectifier's Abramowitz agrees, noting that custom hybrids should cost only 20% more than the price of the devices they carry. "For that, the customer gets assembly, pretesting, and big savings in board space." Lower cost and better performance can be achieved by incorporating logic chips into power hybrids, he says, instead of fabricating smart power chips. On this point, some competitors differ considerably with Abramowitz, particularly GE's Smart and Siliconix's Cooper, whose companies are aggressively developing

*INTEGRATED POWER CIRCUITS FORCE TOUGH DECISIONS ON DESIGNERS*

| Circuit type | Benefits | Drawbacks |
|---|---|---|
| Control ICs with separate power devices | low in cost, available off the shelf | requires original thermal design |
| Custom power ICs | supplies required function and form factor | high development cost, long lead time, no second source |
| Standard power ICs | good thermal performance, easy to apply, and compact | new technology, high price, limited functions, handle only about 30 V and 1.5 A maximum |
| Custom power hybrid circuits | supplies required function and form factor, is fast and inexpensive to develop | volume price higher and size larger than monolithic equivalents |

SOURCE: INTERNATIONAL RECTIFIER CORP.



**HEAT HANDLER.** GE, which makes power hybrids, is mounting a push in monolithic parts for its GE-Smart line using 500-V BiMOS technology.

and pushing monolithic circuits. Motorola is taking a middle course.

Participants aren't sure how much of the market custom approaches will take from standard chips. But Abramowitz estimates it could be in the 20% range when it is more fully developed. Even in depressed 1985, most consultants estimate, total power-chip sales hit the $1 billion-plus range. So this could be a worthwhile business for companies that exploit it, notes Groves.

Any limits on custom-chip growth come not from demand, but from how fast suppliers can move to meet it, says Motorola's Takesuye: "It'll grow as fast as we let it." *–Larry Waller*

***IC PROCESSING***

# FET ARRAYS ARE BUILT WITH ORGANIC THIN FILMS

**CLEVELAND**

The idea that integrated circuits may one day be built partially or entirely from molecular layers of organic compounds might seem like a wild one to those steeped in the culture of chips made with silicon and gallium arsenide. But the concept could gain more credence, thanks to work under way at Case Western Reserve University in Cleveland.

Claiming a first in molecular electronics research, the school's three-year-old Polymer Microdevice Laboratory has successfully processed several 2-in. silicon wafers populated with arrays of FETs that rely on an organic thin-film crystalline layer as the gate dielectric [*Electronics*, Dec. 16, 1985, p. 15]. The organic film replaces the silicon dioxide gate insulator used in conventional FETs.

*Standard IC process puts 400 FETs on a wafer*

"People have built FETs using organic films before. But we're the first to do it in an integrated fashion and in a manner that's compatible with conventional planar silicon-processing techniques," says Scott E. Rickert, codirector of the lab. With about 400 FETs on a wafer, better than 90% yields were achieved on five wafers processed at the lab late last summer, Rickert contends. The electrical parameters of the devices are essentially the same as those seen on conventional FETs, he says. Rickert, an associate professor of macromolecular science and chemical engineering at the university, described the work at a mid-December conference in Cleveland.

The organic gate-insulator layer on the Case Western FETs was fabricated using a technique known as the Langmuir-Blodgett process. The method produces monomolecular lattices of highly ordered organic crystalline materials that are only 20 to 30 Å thick. These can be built up layer upon layer for growing extremely thin films under tight dimensional control.

Named for Nobel Prize winner Irving Langmuir and his assistant Katharine Blodgett for their work done in the 1930s at General Electric Co., Langmuir-Blodgett films are formed when amphiphilic organic molecules in a dilute solution are spread on the surface of a water bath. Because these molecules are part water-loving and part water-hating, they line up in a coherent micromolecular lattice on the water surface with their tails sticking out. These layers can then be polymerized by exposure to ultraviolet light and transferred to a substrate by dipping it up and down through the water surface.

Though some researchers question the ultimate reliability of organic L-B films, these materials have in recent years been the focus of a resurgence of attention aimed at a variety of electronic applications [*Electronics*, May 6, 1985, p. 36]. Erasable optical disks based on organic thin-film materials are nearing the point of commercialization, for example. And a Torrance, Calif., startup, Molecular Electronics Corp., plans by early next year to introduce a new electron-beam resist based on ultrathin L-B films. The new resist promises greatly improved resolution, sensitivity, and contrast ratios compared with conventional inorganic resists, says Josh Reynolds, the company's president. Molecular Electronics also plans alpha tests during next year's first quarter on a proprietary method for continuous batch production of L-B films, Reynolds says.

L-B films can be made orders of magnitude thinner than traditional microfabrication structures, and their mass is only about a third that of silicon. Thus they offer several potential advantages for use in electronic devices, says Case Western's Rickert, including increased miniaturization and lower weight.

Because the films can also be made electrically active, depending on the chemicals used, they also hold promise for developing unique sensor devices for detecting a variety of parameters, including temperature, pressure, and humidity. By using different chemicals for the various monomolecular layers, sensors could be built for detecting more than one parameter at once, Rickert says.

Another potential plus is that L-B films can be prepared at room temperature. This presages simpler, faster, and less expensive semiconductor-processing techniques by eliminating some of the furnace steps required for today's conventional materials, Rickert says. On the other hand, L-B films will melt at about 400°C, rendering them unusable for high-temperature applications.

**PARTNERS SOUGHT.** The Defense Advanced Research Projects Agency, through the Office of Naval Research, is currently funding the Case Western work. That financing, about $2.1 million, covers a five-year period ending in March 1988. Rickert says his lab is looking to sign up corporate partners who want to pursue development of electronic devices based at least partially on organic films.

For the current Case Western devices, dubbed MLS FETs (for metal Langmuir semiconductor FETs), the sources and drains were built with standard methods. All furnace steps came before formation of the organic layer, which would not stand the high temperatures (900°C) of the oxidation furnace. Molecules of 10,12-nonacosadiynoic acid made up the base film.

"We've gone about 50% of the way toward optimizing the process," says Rickert. In addition to developing new device types, the lab plans extensive additional testing on the current MLS FETs. "It's not very desirable to continue to just generate new devices unless you can prove that they can actually work reliably," he explains.

Rickert predicts that "within 5 to 10 years, we could see some active Langmuir films beginning to show up in commercial devices. That means that field tests would have to be started within two to three years." *–Wesley R. Iversen*

# A FIRST? THIS VIDEOTEX MAKES MONEY

**PARIS**

The French Socialist government has done something that has eluded nearly everyone else around the world who has tried: it is now making money, lots of it, on videotex services. No videotex program anywhere has ever met with anything more than the mildest success and most of them have turned into outright fiascoes. Several U. S. experiments failed to get off the ground. In Great Britain, the Prestel system is not generating much activity, primarily because it works with standard TV sets.

The French accomplished their feat by taking a bold, multimillion-dollar gamble. Earlier this year, the government started nationwide distribution of Minitel videotex terminals free of charge to French telephone subscribers [*Electronics*, June 10, 1985, p. 17]. Purchased from French electronic-equipment manufacturers (see "What makes the French successful," below), the terminals are being given out in lieu of standard paper telephone directories. To pay for this hardware, officials of the Direction Générale des Telecommunications (DGT), the French national telephone company, offered to split any revenues generated with those organizations that would provide videotex services. They would get a substantial portion—two thirds—of any additional phone-use revenue their services generated. With the remaining money, the DGT aims to amortize its hardware investment within four years.

Early evidence shows that the government's scheme is paying off. With just 20% of the terminals distributed—about 1.5 million—French telephone subscribers made 16 million calls to videotex services during September. The government's take is a third of a franc—about 4¢—per minute per call.

Half of these calls went to a new electronic telephone directory, the other half to a wide variety of more than 1,500 services created by the country's banks, retailers, professional organizations, service industries, and a growing body of entrepreneurs—all of whom have found that there are substantial amounts of money to be made in videotex.

Georges Nahon, managing director of Intelematique, the organization set up by the DGT to promote the country's videotex technology, believes the creation of a critical mass of users made this effort successful. Other attempts have tried to promote the creation of videotex services and their use at the same time. This approach, he says, results inevitably in a chicken-and-egg situation, where both service users and providers hesitate to make the required initial investment before seeing that it will be justified.

To create that critical mass, the French conceived its electronic telephone directory as the service that would drive the national videotex infrastructure. Consequently, the DGT is now distributing Minitel terminals to subscribers in place of paper directories, with preference given to those whose telephone bills are habitually in the top third of the subscriber list. Subscribers can use the Minitels to access any other videotex service offered. Thus businesses can communicate with and offer pay-interactive services to a large national network of users.

Banks were the first organizations in France to seize on this opportunity by offering home banking services to take some of the pressure off their office staffs. Not far behind were the country's largest retailers, who quickly developed catalog and order services based on the Minitels and the related videotex network. Air France, the domestic rail service, and other travel-related companies began to offer information and reservation services through Minitel.

**ENTREPRENEURIAL SPIRIT.** But perhaps the most striking facet of France's videotex story has been the way in which it has tapped the entrepreneurial spirit of a burgeoning group of independent

## WHAT MAKES THE FRENCH SUCCESSFUL

**Two factors** were primarily responsible for the French videotex success: the Minitel terminals themselves and a creative billing scheme that makes it easy for service providers to cash in on the national installed base of 1.5 million terminals, a figure that could reach 8 million by the end of 1986.

The Minitel is manufactured in France by Matra SA; RTC La Radiotechnique Compélec, the principal French subsidiary of Dutch multinational NV Philips; and Telic-Alcatel, a subsidiary of the nationalized Compagnie Générale d'Electricité, which also owns telecommunications-switch maker CIT-Alcatel.

Consisting of a cathode-ray-tube display, a small fold-away keyboard, and a one-chip modem, the Minitel looks like simplicity itself. It is in fact quite complex.

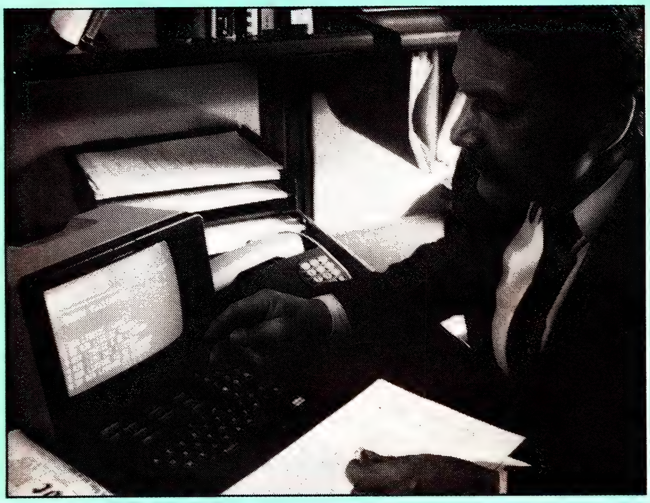
To meet French government specifications, for example, Minitels must be able to withstand a drop from a height of more than 3 ft. In addition, their keyboards—which are based on a magnetic field action—can suffer a glass of spilled water without it affecting their operation. Function keys are clearly marked, and the terminal can be used by people who have no knowledge of data processing.

The terminals cost the French government $155 each in large quantities and can be purchased in lots of 10,000 for $260 each, free on board Paris.

To access videotex services, a French subscriber plugs the terminal into his telephone socket and the telephone plug, in turn, into the socket in the terminal plug. He then dials one of three videotex access numbers and presses a connection button when he hears a tone. He then types the appropriate code to access his service.

The charge for using these services is about one franc per minute, about two thirds of which goes to the person or company providing the service. At current exchange rates, a service with 100 connections thus earns more than $500 an hour.

To inform users about available services, the DGT publishes a catalog periodically. In addition, magazines dedicated to videotex services have appeared. *–R. T. G.*



businessmen. Nahon says an average of one new service a day is created, adding to the 1,500 registered with the DGT as well as several hundred that are not registered.

Using a Minitel, the user can, for example, read the latest news, play computer games, use accounting and professional services, get legal advice, take courses in computer programming or foreign languages, order food and other products for delivery from an electronic supermarket, get information on the current price for used cars and boats, buy oysters from the seashore or goose liver from southwest France and order vintage burgundy or claret to wash it all down with. Users can also read classified ads or create their own.

Perhaps the most efficient generators of new traffic are near-real-time electronic-mailbox services, which have turned into a national electronic social club. Identified only by pseudonyms, French men and women of all ages phone these services to converse with, and finally make the acquaintance of, partners from all over the country.

An idea of just how attractive it can be to offer such services can be seen in the case of François Lagarde, a French physician who gave up his medical practice to develop such a service. Lagarde initially aimed to provide a medical-information service for his colleagues and medical students, but when the service began operation, its message module kept the 30 ports of the computer completely saturated.

Lagarde worked with two colleagues to perfect their Unix-based software until they could handle 150 simultaneous communications on an AT&T Co. 3B-15 minicomputer. Lagarde claims that even this capacity is generally saturated during most waking hours. The partners are studying expansion schemes for their services—an electronic mailbox, various games, and a medical-consultation service. *–Robert T. Gallagher*

# BRITISH MAKE A BIG PUSH IN PHONE-COMPUTERS

**LONDON**

Three British personal computer makers are fighting hard to establish a market that has been extremely slow to develop elsewhere. They have launched desktop terminals that combine the best features of a smart telephone and a personal computer.

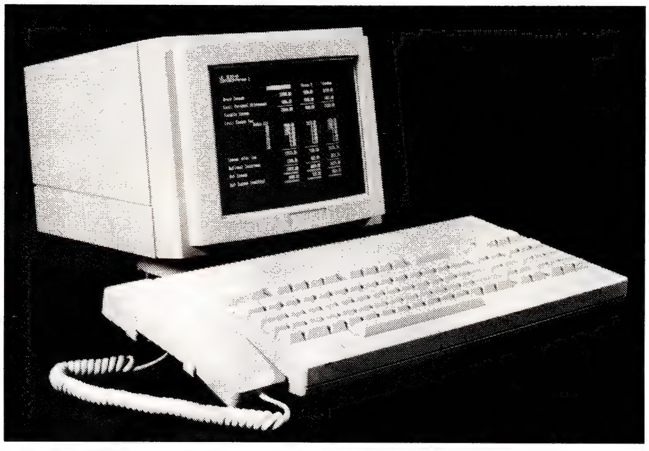
But the barriers to success are many. The three major makers—International Computers, Acorn Computers, and Tandata Marketing—and others readying similar products could be targeting a market segment that will soon be eclipsed at both ends of the price/performance spectrum. France is leading the race to mass-produce a cheap videotex terminal with its standard Minitel unit (see p. 23), while much more powerful personal computers are now acquiring add-on voice and data-communications functions.

The U. S. market for minicomputer-telephone combinations has gotten off to an exceedingly slow start. Potential customers are waiting to see what IBM Corp. does in this area, industry watchers say.

But the British are plunging ahead vigorously, with some initial signs of success. In nine months, ICL sold $42 million worth of the One Per Desk (OPD) product it unveiled in July 1984—the first such product from the UK. Key to the volume have been big contracts from British Telecom and the telecommunications authorities of Australia, Hong Kong, and New Zealand. ICL is seeking OPD type approval in the U. S.

Sales of personal computer-phone sets will be appreciably higher than for videotex systems, says Roy Pendleton, managing director of Tandata Holdings plc, Malvern, England, parent company of Tandata Marketing Ltd., a supplier of videotex modems and terminals. Videotex technology, he points out, was intended to provide a cheap and simple communicating terminal for use in business and the home, and it has now been accepted by British business.

Two months ago, Tandata launched its Personal Assistant, a personal computer-phone system, and last month at Compec, the London computer peripherals exhibition, Acorn Computers Ltd., Cambridge, launched its Communicator.



**NEW BREED.** Acorn's Communicator combines a personal computer with a phone, the latest in a series of British examples of the form.

Acorn has adopted much the same strategy as Compaq Telecommunications in the U. S. Acorn will not sell its Communicator directly but will instead provide a set of building blocks to original-equipment manufacturers, letting others work out the options and prices.

The ICL, Tandata, and Acorn products can all emulate a videotex or mainframe terminal. Protocols such as V.21, V.23, Bell 103, VT-100, and IBM 3270 are supported in firmware. Pairs of protocol-matched terminals can exchange electronic messages through the public telephone network, a hard-wired link, or in some cases a local-area network.

A major point of difference between these systems is whether they are set up to use one or two telephone lines. ICL's unit uses two lines to support data and voice communications simultaneously. The Acorn and Tandata products put voice and data on a single line, a cheaper but less flexible compromise.

All three terminals provide a limited processing capability. They offer easy-to-use functions that support general office staff and middle managers—not the engineer or accountant, who needs more processing power. Tandata's Personal Assistant, for example, incorporates a clock, diary, calendar, alarm, and filing system. It also provides such integrated software functions as a text editor and spreadsheet. The Tandata and the Acorn products store data in battery-backed CMOS memory. ICL currently uses the Sinclair Microdrive in its OPD.

There is a slot for hardware that suits the more casual computer user, says Michael Cooper, director of studies at Quantum Science Corp., London. But to differentiate their products from high-end competition—high-functionality personal computers with special communications facilities from Compaq Telecommunications and others—the UK trio must cut prices to about $700, Cooper says. The Tandata Personal Assistant, for example, sells for just under £1,000 (about $1,400), and ICL's OPD runs $1,700 to $2,300.

In the U. S., where there is no established videotex market to stoke sales, the personal computer-phone market is clearly stuck in low gear while it waits for IBM. Only 50 personal computer-phones were sold in the U. S. last year, and only about 1,000 will move this year, according to Leone Pease, a market-research analyst at Venture Development Corp., Natick, Mass. "Up until this year, there hasn't been much of a market, but then there hasn't been much out there."

There has been more action in terminal-based variations (without full computer functionality). Venture Development defines a class—integrated voice-data terminals—to include personal computer phones, and both smart- and dumb-terminal phones, but not add-on systems for personal computers. All such terminals have 9-in. or larger screens, keyboards, and telephones in one unit. The market total for such terminals hit 23,150 units in 1984, and in 1985 will grow to about 32,000, says Pease. Of those, 23,000 will be dumb terminals such as the Display Phone brought out by Northern Telecom in 1982.

"Over the next five years, smart-terminal phone growth will be about double that of the dumb-terminal phones," says Pease. By 1990, she estimates that 100,000 smart-terminal phones and 87,000 dumb ones will be sold. "The biggest factor that could change the market overnight is IBM. My best estimate is that IBM will introduce the next-generation PC sometime in 1987—the PC Phone—and IBM's PC phones will change the market numbers dramatically." If that should happen, personal computer-phone sales will suddenly balloon to between 900,000 and 1.1 million, she says. *-Kevin Smith and Tobias Naegele*

**SOFTWARE**

# LANGUAGE BOILS DOWN BOOLEAN EXPRESSIONS

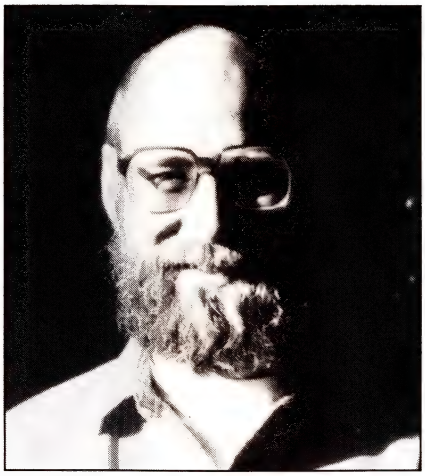
**MOUNTAIN VIEW, CALIF.**

There are 24 different ways to express a syllogism in logic, and every single one of them is right. They can, however, be condensed into a single canonical form using Losp, a new computer language based on an innovative and controversial calculus called the Laws of Form. Losp's author, William M. Bricken, senior research scientist at Advanced Decision Systems, has put the language to work immediately as a code optimizer. Its structure also makes it useful, he says, in breaking up problems for parallel processing and introducing new variables in machine-learning and artificial-intelligence applications.

Losp is a research project at the Mountain View company, a military-oriented software house. Currently written in Lisp, the language is being microcoded to run directly on a Symbolics Inc. work station. Programs written in Lisp or Prolog will then be translated to Losp, simplified, and then retranslated to the originals. Not only does this process result in more compact code, Bricken says, but it also tends to smooth out differences in coding style on a large project and makes debugging of complex programs easier.

**EQUIVALENCIES.** Boolean logic expresses a syllogism different ways because of the equivalence of such statements as "If it hails, it freezes," and "either it doesn't hail, or it freezes." The Boolean operator Implies expresses the same value as NOT plus OR.

These and similar equivalencies can be simplified conventionally according to a variety of heuristic rules, but Losp takes a different approach. It uses only a single operator, so that there is only one way to express a statement. And it makes simplification of an expression easier by allowing no representation for the semantic concept of "false."



**CANONIZER.** William Bricken developed Losp to reduce equivalent forms of a logic expression to a single canonical form.

How Losp works can be seen in the way it expresses one of the De Morgan laws for logical equivalence. The law written in Boolean notation as

NOT (a OR b) = (NOT a) AND (NOT b)

is expressed as

(a b) = ( ((a)) ((b)) )

in Losp. Expressions inside a parenthesis are negated with respect to those outside. Double parentheses in Losp may be erased, so the equation above immediately reduces to the identity

(a b) = (a b).

Proof of the equivalence, which requires many steps in Boolean notation, is thus given by a single algorithmic step (erasing the double parenthesis) in Losp.

The operator, which Bricken calls a "parens" because it is represented as a parenthesis, has the single property of containment. Variables and other parens operators in an expression are either contained or not contained in parens, which may be nested to any depth and concatenated serially to any length.

In Losp, an expression that reduces to an empty parens has the value true; one that reduces to no representation has the value false. A variable itself can be either of the two values; expressions that contain variables when reduced are contingent upon them.

Any statement written in Losp may be simplified (or complicated) according to transformation rules that maintain the truth value of an expression. There are four ways of erasing expressions in a logical statement, and one way of moving variables in and out of parens. They are all derived from the mapping into logic of Laws of Form, a nonnumerical calculus developed in the 1960s by G. Spencer-Brown, a British mathemetician who studied with Bertrand Russell and Ludwig Wittgenstein.

Spencer-Brown describes Laws of Form as the "arithmetic" to Boolean algebra, or the study of logical constants rather than logical variables. Spencer-Brown was the first to examine the arithmetic of Boolean algebra.

The one constant recognized by Spencer-Brown is the distinction between one state and another. Any such distinction, he says, can be made by a single mark in one of the states. In this way, he does away with a second token and achieves some breathtaking simplifications when the calculus is applied to logic.

**UNWELCOME.** The Laws of Form were praised by Russell as a calculus of great simplicity and power; but they have not been widely welcomed by mathematicians. Paul Cull and William Frank of the University of Oregon claim that Spencer-Brown merely reinvented Boolean algebra and in the process violated "the most basic truth of information theory: at least two symbols are required to convey information."

But Spencer-Brown says that using a single symbol plus the absence of that symbol amounts to the same thing. Adds Bricken: "If you have two bags, one containing a sandwich, a label on one of them is enough to tell which has the sandwich."

Advanced Decision Systems will use Losp in an Air Force project on pictorial logic, where it is useful because the Losp operator is topological, identifying boundaries. Beyond that, Bricken sees far-reaching applications in parallel programming, because any expression inside a parens may be executed independently of the rest of a logical statement.

Losp also offers a more direct path to proving theorems, Bricken says, because of the ease with which it simplifies logical statements. And if the Losp transformation rules are used to construct complex expressions, rather than to simplify them, the language has potential in artificial intelligence and machine learning. The rules, Bricken explains, allow introduction of new variables into an expression without changing its overall value. That means that AI systems can experiment with variables that have not been programmed in.

Bricken contends that the use of a single operator and the elimination of a token for the value false represent a significant innovation in the methodology of logic. "Formal logic is really still in its infancy. Until the Laws of Form appeared, no one had ever used nonrepresentation to convey information. Spencer-Brown may be the first truly modern logician." *–Clifford Barney*

### *ARTIFICIAL INTELLIGENCE*

# EXPERT SYSTEM MAKES IT EASY TO FIX INSTRUMENTS

**SUNNYVALE, CALIF.**

Every year, Lockheed Missiles and Space Co. must calibrate and repair some 55,000 of its electronic instruments. To automate this staggering task, the giant defense contractor has adapted a "generic" expert system to perform diagnostics in a way that mimics a human technician. In this way, a human can more easily figure out where the system went wrong when it can't come up with an answer, says Lockheed engineer Michael P. Prevost.

The generic system—LES, for Lockheed Expert System—is written in Ada and consists of a set of data structures that may be used for attributes of both the system under test and the control system that determines which tests to make. Having such easy access to the control system enables LES to change its goals on the fly after receiving new information or starting a new test. It is this flexibility that gives the system its human-like quality.

Prevost and Thomas J. Laffey of Lockheed's Palo Alto research laboratory have put LES to work on a Hewlett-Packard Co. 6130C digital voltage source. With a knowledge base that includes information on the 6130C's operation, LES has correctly diagnosed faults that were deliberately planted for testing purposes.

**DEMON PRIORITIES.** The HP 6130C contains 9 circuit boards, 39 circuits, and some 300 components. Rather than test each of these according to a preset routine, LES uses two kinds of heuristic rules. An If-Then set embodies knowledge about specific faults in the voltage source. When-Then rules determine which faults to look for. LES personifies the latter rules as a "demon" that runs the system by setting priorities.

The demon comes alive when certain events occur, such as the isolation of a fault to a particular board or the discovery of an out-of-tolerance value. The When rules then reset the priorities of the If-rule sets. Several If-rule sets may be operating at one time, with a separate decision tree for each goal, but the priorities may differ. If a board-level test seems to point directly at a certain component, the demon can bypass the circuit level, just as a technician would, and put highest priority on testing that particular component.

LES, possibly the first expert system written in Ada, runs on a Digital Equipment Corp. VAX-11/780 (Lockheed will switch to a MicroVAX next spring). Ada is slower than LES's initial implementation in PL-1, says Walter Perkins, one of the system's designers. Ada does provide a good maintenance environment with many checking procedures, however. That's very useful in a large program, Perkins says.

Lockheed has now applied LES to nearly 20 projects, including fault diagnosis in a signal-switching system and rule checking for computer-aided design. The instrumentation diagnostics tested well on simulated faults. Prevost says he will not be satisfied, however, until they are field-tested. That may take some time because the 6130Cs don't often fail.

The next step for Lockheed will be to generalize the processes used in diagnosing the 6130C across a broad range of instrumentation. One of the purposes of the first experiment, Prevost says, was to see how much of an existing knowledge base can be preserved and to determine which rules are general and which specific. First indications are that instruments behave pretty much the same at the circuit level and below, where an amplifier is an amplifier and a transistor is a transistor. At the board level and above, Prevost says, systems tend to be unique. *–Clifford Barney*

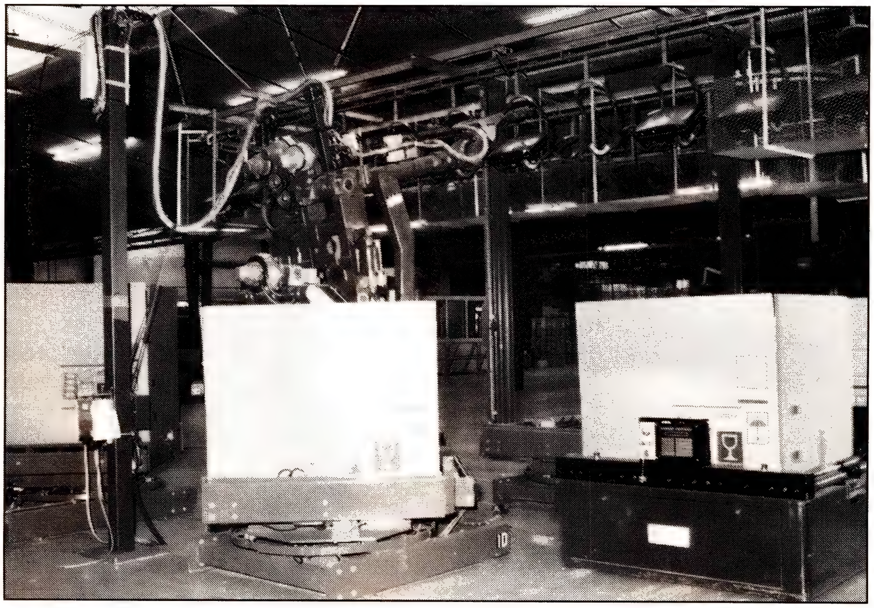
### *AUTOMATION*

# FRENCH MAKER RETOOLS TO FIGHT THE JAPANESE

**DREUX, FRANCE**

Anyone who thinks Europe's embattled consumer electronics industry is ready to throw in the towel and concede to its Japanese competition should visit RTC La Radiotechnique Compélec's cathode-ray-tube factory, 50 miles west of Paris. RTC, the principal French components-producing subsidiary of Dutch multinational Philips, has invested about $100 million to turn the plant into a paragon of productivity and modernity.

The highly automated factory turns out color CRTs at the rate of 1.5 million



**NO HANDS.** A robot packs CRTs into cartons at RTC's ultra-automated Dreux plant.

LOOK
WHO'S
BACK.

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## In the first half of 1985, Electronics featured 86 articles on computer systems. 50 on software. 33 on boards and peripherals. 28 on CAD/CAM. And here are just a few of them:

### January

- New System Aids Blind Operators
- Domino-Like Modules Build Computers
- Expert System Uses AI for Natural Sound
- Home PCs Move Upscale
- Convergent Recruits HP's Ely as Chief
- Add-Ons Turn IBM PCs into Unix Systems
- Computers at the Helm
- Computer Crime Problem Grows
- UNIX has Growing Pains

### February

- Investment Shifts in AI
- Has AI's Time Come at Last?
- Locking Up System Security
- PC Digitizes Images Quickly
- University Grant Unveils HP AI System
- Head of Startup ELXSI, Vigil Takes on Computer Goliath

### March

- Kaypo Eyes PC Clone War II
- Olivetti Picks Up Britain's Fallen Acorn
- UNIX Update: Coming of Age
- UNIX Gets Office-Friendly
- NEC's CPU Leapfrogs IBM
- Sippl Wants to Help Unix Hook Business Market
- Opportunity Knocks Twice for Founder of Stratus Computer
- Hitachi CPU Challenges IBM
- Video Disk, Personal Computer Replace Lab
- TI Takes Aim at PC-AT Market
- Computer is Ready for Nets

### April

- Burroughs, Honeywell Join IBM's Sierra Club
- Columbia Unveils Non-Von Prototype
- Olivetti Stakes Claim in Video Typewriters
- Minis Shedding High-End Image
- Showing Off GEM, Kildall Hopes to Attract Computer Makers
- PC Mimic Sits in the Lap
- IBM Still Seeks Smaller, Cheaper Devices
- Money Starting to Flow as Parallel Processing Gets Hot
- Hanna of Dataport Makes a Swedish Connection
- CAD/CAM Work Stations Get More Personal
- Lucafilm Eyes Role in Computer
- Britain Promotes Open Architecture
- Risc Technology Moves Off Campus into Commercial Machine
- Zenith Data Systems Moves Quietly Ahead

### May

- IBM PC & Instruments Tackle Development Problems
- Parallel Machine Expands Indefinitely
- NCR Challenges IBM PC: Faster Units & Lower Prices
- Sales to China Are a Bright Spot for Computer Business
- Home Computer Makers Anxiously Seek Jobs for Machines
- DEC's Latest Work Station Uses the Vax-on-a-Chip

### June

- Harris Goes After DEC with a Risk Architecture
- Apple to Concentrate on its Core Business
- Optical Computing Beginning to Take on Glow of Reality
- Personal Computer Putting Squeeze on Digital PABX Voice Mail
- Apple Tries Again to Blast Off in Japan
- Philip's Adaptor Box Simplifies Coding, Editing
- Silicon Compilers Adds Two VLSI Design Systems
- Fresh Muscle Fills Gap Between Superminis & Supercomputers
- Bell Issues Challenge to Computer Makers
- Gold Hill Computer Gives IBM PCs the Smarts

# SHOULDN'T YOU BE BACK?

a year with a total of 1,400 employees. The company won't give figures on cost savings but says modernization has cut production costs and resulted in a higher yield of tubes. What's more, by the end of 1986, RTC will switch over to 100% production of the flat, square tubes that are expected to gain increasing use in TV sets. These tubes already make up one third of RTC's line.

"We are at least as advanced as the Japanese are"

Company president Jacques Bouyer admits that some Japanese companies are doubling his production numbers in their factories, but says those totals include all sizes of tubes. RTC makes only 26-in. and 23.2-in. models at Dreux and buys the balance of its requirements from other manufacturers within the Philips group.

"We have absolutely no inferiority complex in being compared with the Japanese," declares Bouyer. "We are at least as advanced as they are, both technologically and in terms of production."

European manufacturers supplied robots and automation systems for the Dreux factory's revamping, but RTC's own team developed all the control software. These systems include proprietary machine-vision apparatus enabling the robots to distinguish between the two tube sizes for testing and packaging.

Certain sections of the plant are almost eerie with their lack of production workers. In one, robots distribute liquid luminescent material on the tubes' screens and then spin them to spread it evenly by centrifugal force. In a test area, robots plug the CRTs into testing banks and then remove them, discarding those that fail. Perhaps most impressive is a packaging area in which robots remove the tubes from a supply line according to size and pack them into cartons containing preformed Styrofoam supports. Full cartons are automatically removed and replaced.

The only areas still requiring significant manual work are those in which the CRTs' delicate shadow masks are fitted to their frames and a final test area where fine tuning is done. RTC plans to automate more manual operations next year. *–Robert T. Gallagher*

**NETWORKING**

# PHILIPS LOCAL-AREA NET EMPLOYS FIBER OPTICS

**GELDROP, THE NETHERLANDS**

No less a telecommunications giant than Philips is experimenting with fiber optics for a local-area network. At this stage of product development, such efforts usually go on only at smaller or startup companies.

Called Philan, the Philips LAN offers simultaneous transmission of voice and data, built-in error and flow control, and—thanks to a meandering-ring structure—reduced cable costs.

Developed at the Philips research laboratories in Eindhoven, the system is installed at the company's Geldrop Project Center in this southern Dutch town. Philips does not intend Philan to be a product prototype, but the company is demonstrating it and studying its potential. Designed for commercial environments, Philan uses glass fibers, the time-division multiplex (TDM) transmission method, and a meander structure. The versatile LAN can function as a circuit-switching or packet-switching network.

Fred Snijders, the Philan project leader, says the LAN's meander structure, which is an extension of the segmented-ring concept, is unique to Philan. To limit the effects of a fault somewhere in the network, the ring is subdivided into a number of bypassable loops or meanders, each one linking about 10 stations. If transmission fails in either a single terminal or an entire subloop, a switch bypasses the information flow around that part of the network.

**COST CUTTING.** Snijders says cable costs for this type of LAN are less than those for established segmented-ring concepts because return links from the stations to the network's central control unit are unnecessary.

Philan spans 6 km and can link several hundred user stations. It can connect electronic mail services and office equipment, ranging from telephones and Telex machines to word-processing and data-storage and -retrieval systems.

Philips chose glass fibers as the transmission medium not only for their high bandwidth but also to ensure reliability, even in noisy factory environments.

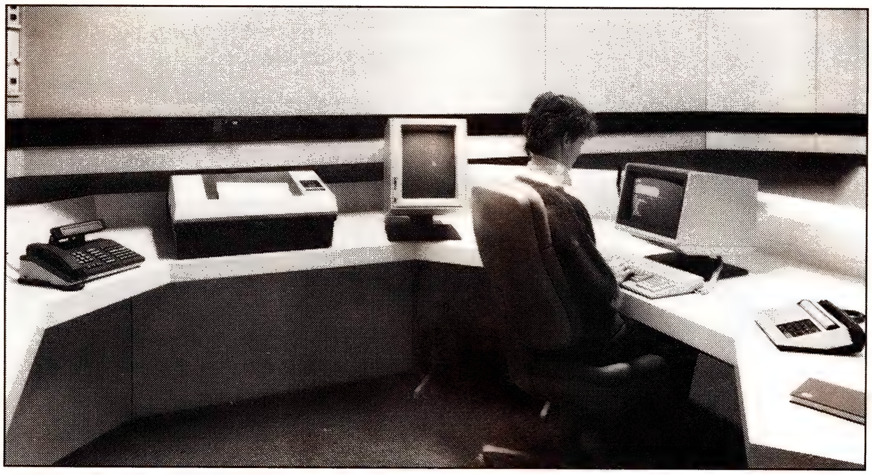
Each station connects to the ring as a circuit that first stores the signals to be transferred—after digitization, if necessary—and then delivers them to the ring at a rate of 20.48 MHz, the clock frequency generated by the central control unit.

To exploit the optical fibers' large bandwidth effectively and to permit the simultaneous transfer of many information packets among the stations, the Philips designers settled on TDM as the transmission method. This gives the network a capacity of more than 20 Mb/s, which can be split up on demand into a number of independent channels.

In addition to high capacity, a TDM network is far easier to expand or reconfigure to meet varying traffic requirements than a frequency-division multiplex net, Snijders says. This is because software can handle the process of splitting up the capacity into individual channels, either automatically or by an operator. A ring-management system keeps tabs on the TDM structure and guards the user channels against duplication or loss of channel numbers.

Philan's versatility is demonstrated by the variety of communications services the system can handle. Functioning as a circuit-switching network, it accommodates continuous traffic such as speech or video communications and intermachine dialogues. As a packet-switching network, it handles the intermittent traffic between word processors, terminals, host computers, archiving equipment, and other data-handling gear.

"The combination of circuit- and packet-switching functions in a single system marks the latest generation of LANs," says Snijders. *–John Gosch*



**INTEGRATED.** Phones and computer hardware are linked by Philips' fiber-optic LAN.

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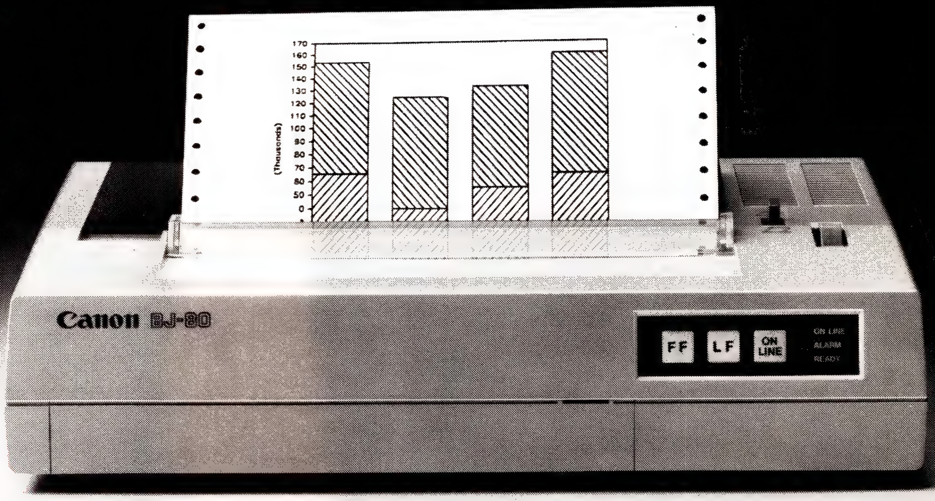

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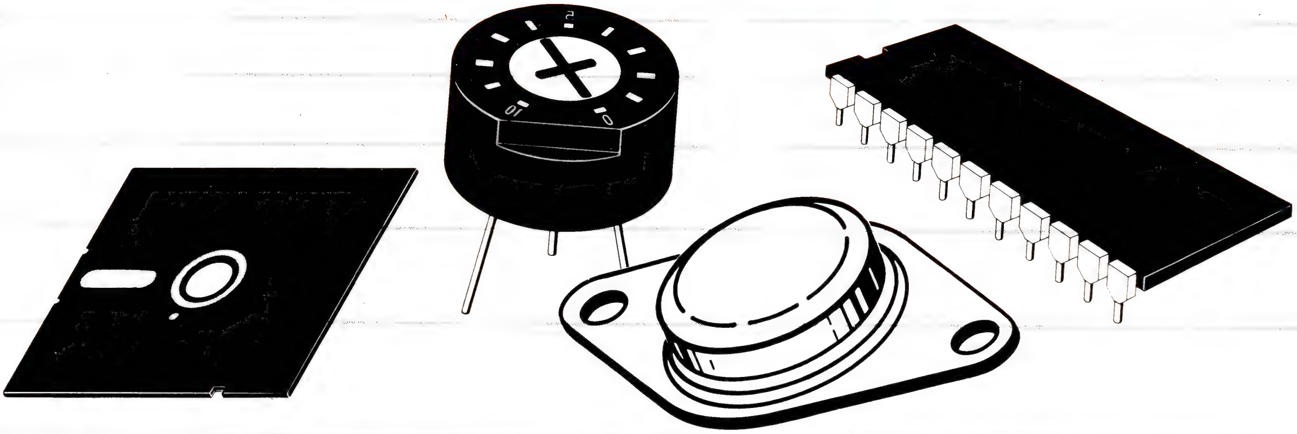

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## INSIDE TECHNOLOGY

# CAD, CMOS, AND VLSI ARE CHANGING ANALOG WORLD

## ANALOG CHIPS FOLLOW IN DIGITAL'S FOOTSTEPS

*by Bernard Conrad Cole*

Even a cursory examination of the analog segment of the integrated-circuit industry evokes feelings of déjà vu. Both technologically and structurally, the analog-IC industry is undergoing the same radical changes already experienced by its digital-IC sibling. Rapidly escalating chip complexity and density are providing concomitant gains in functionality; a significant shift is developing toward CMOS technology from bipolar; and a growing library of computer-aided-design tools is speeding the move toward application-specific linear arrays and cells.

Taking care to maintain their dominance in the analog market, U. S. companies are continuing to introduce a blizzard of products with ever higher densities and speeds, in both bipolar and CMOS processes. To expand their user base, many companies have developed a variety of CAD tools and semicustom methodologies aimed at making it easier for designers to work with analog circuits and to develop analog ICs for particular applications. And CMOS vendors are increasing their attack on bipolar techniques with the processes that combine features of bipolar and CMOS.

Though data converters and interface circuits originally used bipolar processes, these segments are now largely the domain of CMOS. Bipolar still dominates high-performance circuits, but even here there is an increasing effort to introduce CMOS or designs that mix the two.

Most building blocks, of which operational amplifiers constitute almost 75%, are built with bipolar technology, with CMOS used only at the low end. For example, almost 75% of the 2,000 different types of op amps are bipolar. At the low end, dominated by such companies as National Semiconductor, Analog Devices, and Texas Instruments, op amps are fabricated using a process that retains the bipolar core but use FET inputs and outputs. Mixed processes represent only 5% of the op-amp market. CMOS dominates dedicated and special-function circuits for such applications as telecommunications and automotive equipment, which in common with data conversion require large amounts of analog and digital functions on one IC.

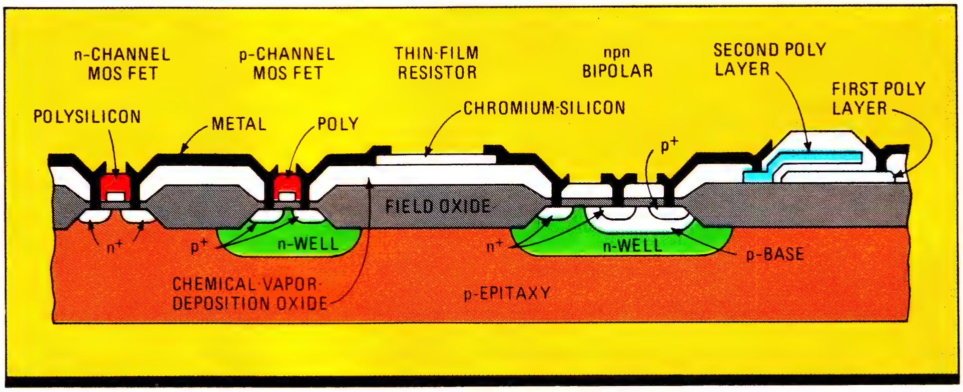
The reasons for such differentiation in the market lie in the basic characteristics of bipolar and CMOS circuits, says Robert Dobkin, vice president of engineering at Linear Technology Corp., Milpitas, Calif. For example, analog CMOS has the advantage of allowing fabrication of excellent analog switches and precisely matched capacitors, zener diodes, and parasitic bipolar transistors. MOS FET structures feature very high input impedances combined with very low input current, along with input common-mode voltage ranges that can swing from rail to rail. This is because n- and p-channel FETs have similar bandwidths when implemented in a p-well, making possible a good output pair with rail-to-rail swings and the ability to drive loads as high as 2 MΩ.

Also contributing to CMOS's advantages is that a FET will slew much faster than a bipolar transistor for equivalent bandwidths. But CMOS's greatest plus is that it allows designers to build highly complex circuits—system-on-a-chip structures that combine digital logic and analog functions. Though these circuits are not up to bipolar's performance, they are acceptable in a monolithic design. Finally, CMOS allows true single-supply operation. Bipolar's strong points are higher gain, more precise matching of critical parameters, lower noise, and higher operating voltages, as well as better dc specifications, particularly higher precision, says Robert Blauschild, linear-design consultant at Signetics Corp., Sunnyvale, Calif.

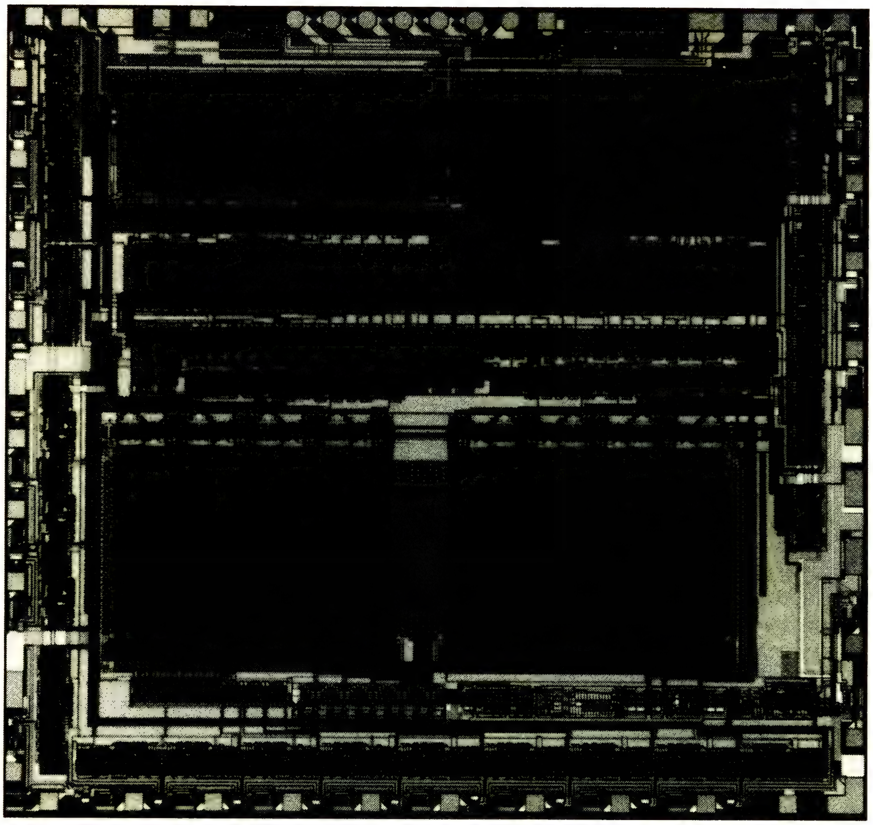
### MIXED PROCESSES

To get around CMOS's limitations, many companies are turning to processes that combine it with bipolar structures. These mixed processes go beyond simply taking advantage of the parasitic bipolar structures inherent in the complementary process. Bimos II, a mixed process developed by Analog Devices Inc., Wilmington, Mass., for use in fabricating high-performance data converters, merges a junction-isolated buried layer on an epitaxial substrate with aluminum-gate CMOS and thin-film resistors. This allows the fabrication of one chip with vertical npn and pnp transistors, bifets, and p- and n-MOS transistors. BidFet, from Texas Instruments Inc., Dallas, combines double-diffused MOS with n- and p-channel MOS FETs and npn transistors on one chip. Bi-Dmos, from Motorola Inc.'s Semiconductor Products Division, Phoenix, Ariz., combines metal-gate CMOS, DMOS and npn transistors and is intended for use in op amps and voltage regulators.

An indication of future developments can be seen in a new



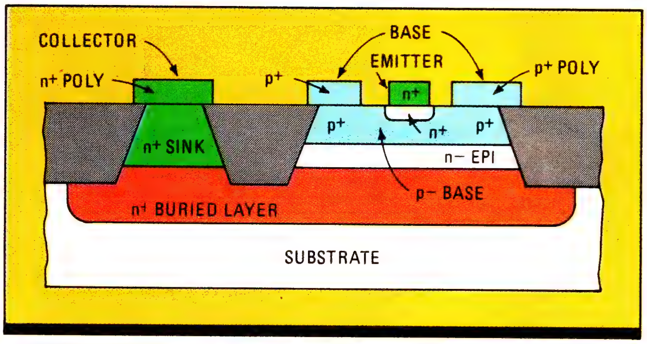
**1. ANALOG CMOS.** A new 1.2-μm analog CMOS process from Honeywell allows 10-V analog operation as well as very large-scale-integration packaging densities and performance.



**2. SYSTEMS APPROACH.** Using its bipolar IMOX process, Advanced Micro Devices has built a graphics IC combining color lookup tables and a video digital-to-analog converter on one chip.

mixed process (Fig. 1) under development at Honeywell Inc.'s Solid State Electronics Division, Colorado Springs. This extension of the 1.2-μm, single-poly, two-layer-metal CMOS process used for digital circuits adds only three masking steps to the original 11: a capacitor poly layer, an active base implant, and fabrication of chromium-silicon resistors. An n-well process is used so that vertical npn transistors can be fabricated easily. The collector is formed by the n well and the emitter from the n+ source-and-drain implant. An extra masking step then defines the active base areas, and a multiple boron implant achieves the appropriate bipolar parameters. Poly capacitors are added to the process by growing a second gate oxide, and Cr-Si resistors are formed by a process that combines wet and dry etching.

The resistors are formed after passivation of the second poly layer but before the contacts are defined. Multilayer metalization is used to pattern the resistors. With this process, the company has developed a wide range of analog macrocells—including analog-to-digital and digital-to-analog converters, second-order low-pass filters using switched capacitors, and a band-gap reference—for such applications as high-performance data conversion and signal processing.



**3. SINGLE-POLY PROCESS.** Fairchild researchers have developed a single-level polysilicon bipolar emitter-coupled-logic process that integrates analog and digital functions on one IC.

Also in development is a fine-geometry analog CMOS process from General Electric's Corporate Research and Development Center, Schenectady, N. Y. Featuring two layers of metal and 1.25-μm geometries, this process incorporates molybdenum resistors and isolated metal-to-metal capacitors. It has been used to fabricate a 7-bit flash ADC in the 100-MHz range, high-frequency stacked-mirror and cascade op amps with 70-MHz gain bandwidth and 68-dB dc gain. Switched-capacitor filters fabricated in single- and double-layer metal have operated successfully at 15 MHz. Other circuits include a 200-MHz voltage controlled oscillator and a 150-MHz 20-dB wideband amplifier.

One of the most advanced mixed processes in production is running in Santa Clara, Calif., at Micro Power Systems Inc. It combines scalable molybdenum-gate CMOS with a double-diffused buried-layer bipolar process providing both vertical and lateral pnp transistors and vertical npns with buried layers. This approach keeps the interconnections for bipolar and CMOS devices completely separate, unlike silicon gate, according to company president John H. Hall. In addition, the buried layer makes possible buried zener references.

Using this technology, the company has developed the MP7685, an 11-bit parallel, or flash, ADC that features a 2-MHz sample rate, 11-bit resolution, and ±½-bit accuracy. The converter's two-layer interconnection technology is based on the company's molybdenum-based process, which yields a very low resistance of 0.2 Ω per square. The result is time delays of only 0.5 ps per 10-μm length. The molybdenum pattern is etched with a dry-plasma process that produces precision matched resistors. This is essential for the converter's voltage divider, which quantifies input analog-signal levels.

Manufacturers of bipolar analog circuits, particularly data converters, have reacted to the continuing invasion of CMOS circuits into their domain by pushing their monolithic circuits into the higher-performance arena previously occupied by hybrid devices. One particularly competitive area is video signal processing. At least three companies—Honeywell, Analog Devices, and Signetics—have developed high-performance bipolar triple DACs for video-color-graphics applications, which require data-update rates in the 125- to 300-MHz range. At Honeywell, designers have developed the DAC34010 and DAC34020 using an advanced bipolar process, compatible with emitter-coupled logic, that allows conversion rates up to 200 million words a second.

## COLOR GRAPHICS

Approaching video conversion from the systems level, Advanced Micro Devices Inc., Sunnyvale, has applied an advanced version of its IMOX bipolar process to fabricating the Am8151 graphics color palette (Fig. 2) incorporating a color lookup table and a video DAC on a single chip. The chip incorporates overlay, blanking, and sync-level logic as well as a 256-level gray scale. Its three levels of internal pipelining yield a pixel rate of 200 MHz. With three such ICs connected in parallel, it is possible to simultaneously display 256 colors from a palette of over 16 million color variations.

Taking a completely different tack to address the increased competition from CMOS is Fairchild Camera & Instrument Corp.'s Research and Development Center, Palo Alto, where researchers have developed a high-speed, high-density, single-poly ECL technology that can be used to combine analog and digital functions on one chip. Using 2-$\mu$m design rules, gate delays of 200 ps and toggle frequencies as high as 8 GHz have been achieved. This self-aligned process (Fig. 3) uses single-level poly, which, with proper doping forms the base, emitter, and collector contacts of the transistors, provides high density and high speed. A variety of digital and analog macrocells has been designed and tested, and researchers say it is possible to use the technique to fabricate high-performance 8- to 10-bit data converters without trimming.

With the increased complexity and flexibility of such advanced processes comes increased design complexity, says Michael Parsin, analog strategic marketing manager at Raytheon Co.'s Semiconductor Division, Mountain View, Calif. Like their digital brethren, many analog-circuit manufacturers—including several startups—are developing semicustom-array and standard-cell methodologies along with CAD tools honed to analog technology to handle this complexity while expanding their market. In addition, most standard-cell vendors, such as Gould/AMI, NCR, and Zymos, offer various analog functions as part of the library of standard-cell and megacell functions.

Raytheon's solution is the RLA120 (Fig. 4), says Parsin, a new analog macrocell array chip for applications that require networks of transistors, thin-film resistors, and differential gain blocks configured as op amps and voltage comparators. It is fabricated with an advanced, proprietary, two-metal-layer bipolar process also used in making the company's digital gate arrays. Connected by the bottom layer of metal are the various architectural and structural components, including 12 macrocell gain blocks, 55 independent small signal transistors (16 pnp and 39 npn, all capable of 36-V operation), four switching transistors of the 100-mA npn-type, and 176 resistors with values ranging from 1.25 to 150 k$\Omega$.

There are 148 aluminum cross-under feedthroughs, each with a resistance of only 0.05 $\Omega$. The bottom layer also routes the power-supply buses to simplify the top metal layer of the design. The top-metal-layer mask connects the various components and is customized at the factory to the user's functional circuit specifications.

## PROGRAMMABLE MACROS

All the macrocells can be programmed for specific quiescent currents and ac operating conditions. "Most users of op amps, for example, are concerned primarily with an amplifier's gain-bandwidth product," Parsin says. "A designer who creates filters, on the other hand, makes certain that an amplifier has sufficient gain at a specific frequency." In addition, the bandwidth and power of the RLA120 can be tailored for any situation. "For example, if the design is intended to run at a very low frequency, the macrocell can be programmed to run at a very low current to save power."

Using a slightly different approach is the new Macrochip gridded analog series (Fig. 5) from Ferranti Interdesign Inc., Scotts Valley, Calif. Each Macrochip begins with transistor and resistor cell blocks having identical performance and layout. Utilizing a 20-V bipolar process with a collector-sinker diffusion to minimize saturation voltage, each Macrochip begins with transistor and resistor cell blocks that include small npn transistors, lateral pnp transistors, diffused resistors, pinch resistors and diodes.

The small-geometry npn transistors with either single or dual bases or emitters are the primary components being employed to provide usable current gain at collector currents from several nanoamperes to more than 10 mA. Lateral pnp transistors, in which the emitter current flows side-

## MAJOR GROWTH IS IN THE CARDS FOR ANALOG ICs

**Although annual U. S. sales** of analog circuits are expected to drop from $274 million in 1984 to $230 million in 1985, the pause should be momentary, according to Dataquest Inc. By 1990, U. S. sales will grow to $400 million, the San Jose, Calif., market researcher predicts.

The outlook for worldwide sales is even better: the market in its entirety should grow at a steady 11% compounded annual growth rate. Total worldwide sales are expected to grow from $1.2 billion this year to $2 billion by 1990.

Although the schemes for classifying analog ICs are somewhat arbitrary, reflecting the bias of the particular vendor, it is generally agreed that the market has three segments:

The first comprises classical pure linear building-block functions, such as operational amplifiers, voltage comparators and references, and regulators. Together they represent 34.5% of the market.

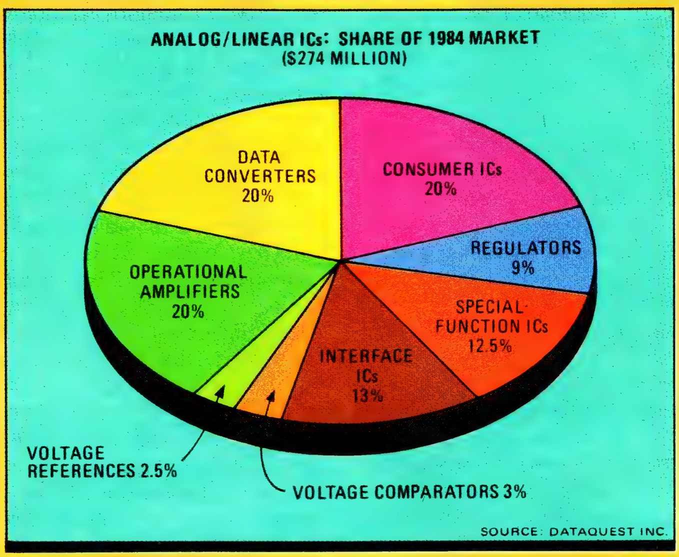
In the second group are general-purpose ICs that combine both analog and digital circuitry, primarily data-conversion and interface circuits, which represent 33% of the total market.

The third group covers special-function and dedicated-function circuits for consumer, entertainment, telecommunications, and automotive applications, which constitute the other third of the total market for analog circuits.

Of all these segments, the fastest growing area is general-purpose ICs combining both analog and digital circuitry, where the annual growth rate is 11.7% for data converters and 12% for interface circuits. Certain segments of the dedicated-function circuit market, such as telecommunications, are growing 20% to 30% a year. However, because U. S. consumption of consumer circuits is declining, their overall growth per year is projected at only 11.1%.

What is remarkable about the analog market, however, is not its relative stability. Rather, it's the fact that—unlike the memory, microprocessor, and gate-array segments—it is dominated by U. S and European vendors, with little or no competition from Japanese makers.

"In general this is because linear circuits, and data-conversion ICs in particular, don't lend themselves to commodity-type production," says Paul E. Standish, director of linear-IC marketing at National Semiconductor Corp., Santa Clara, Calif. "All linear/analog circuits, to some degree or another, incorporate features which are specific to particular market and user segments."



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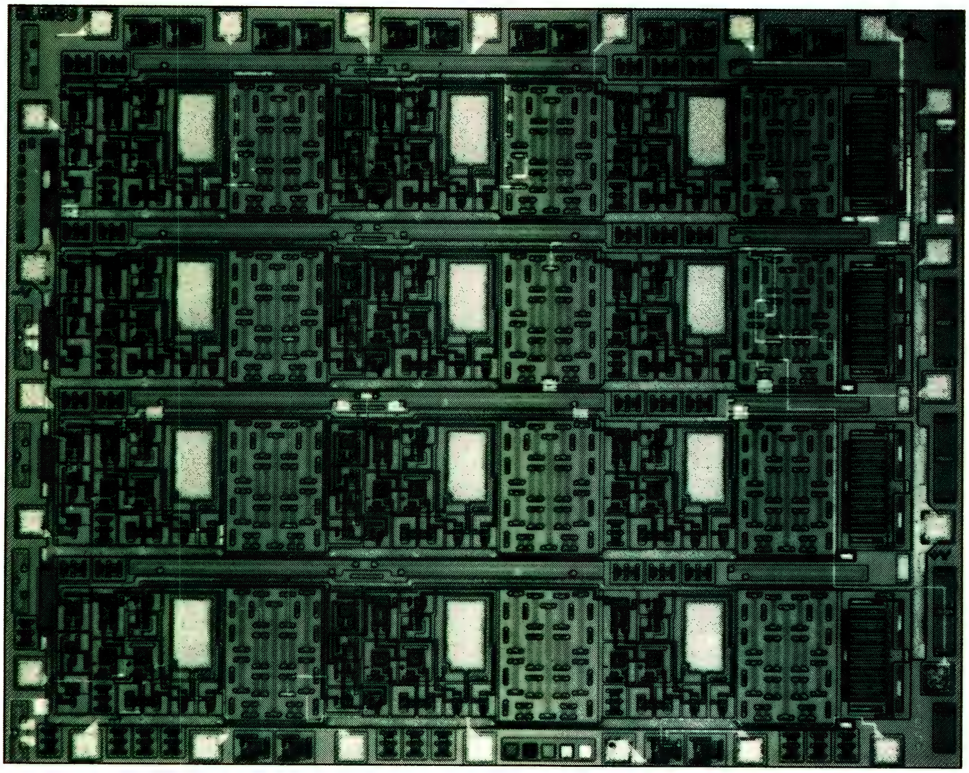


**4. ANALOG ASIC.** A macrocell array from Raytheon allows construction of customized analog ICs from such basic building blocks as operational amplifiers and voltage comparators.

ways from the p emitter to a p collector ring that surrounds the emitter, are provided on all Macrochips.

In addition, the cell structure is supported by a library of macros, including a Norton amplifier, one op amp with a pnp input and one with an npn input, control-current comparator, window detector, timer, D-type flip-flop, master/slave flip-flop, one- and four-cell sample-and-hold circuits, series bandgap reference, bandgap regulator, transconductance amplifier, absolute-value differential amplifier, high-speed comparator, wideband 733-type amplifier, emitter-coupled oscillator, LM139-type comparator, a 741-type op amp, a triangle oscillator, and a LM124-type op amp.

The Quickchip series of analog bipolar semicustom arrays from Tektronix Inc., Beaverton, Ore., is aimed at such high-performance applications as pulse generators, phase-locked loops, triple DACs, Schmitt triggers, gigahertz-range preamplifiers, and high-performance analog switches. These circuits have a junction-isolated dual-metal-layer bipolar process capable of toggle frequencies as high as 6.5 GHz and a collector-to-base breakdown voltage of 15 V.

## CUSTOMIZED ROUTING

The basic core of each array consists of transistors, resistors, and macros suitable for remetalization. Working with a grid-based layout system, the user can specify where custom interconnections should be routed, reducing complex design rules to a simple representation. The basic Quickchip 2 array has 214 npn and 110 pnp transistors organized into 10 full cells and two half cells, with 946 resistors and 40 programmable capacitors around the periphery to ease the design of high-performance custom circuits.

Micro Linear Corp.'s analog array is fabricated with a high-density, 12-V, 1-GHz bipolar process that includes ion-implanted resistors and capacitors. The array makes use of what the San Jose, Calif., company calls a "mosaic," in which an identical grouping of devices called a "tile" is repeated regularly on the chip. Within each tile are npn and pnp transistors of various configurations, resistors, and a capacitor. Also offered is a macrocell library that includes such analog building blocks as analog output buffers, transconductance op amps, video amps, a modem, and comparators.

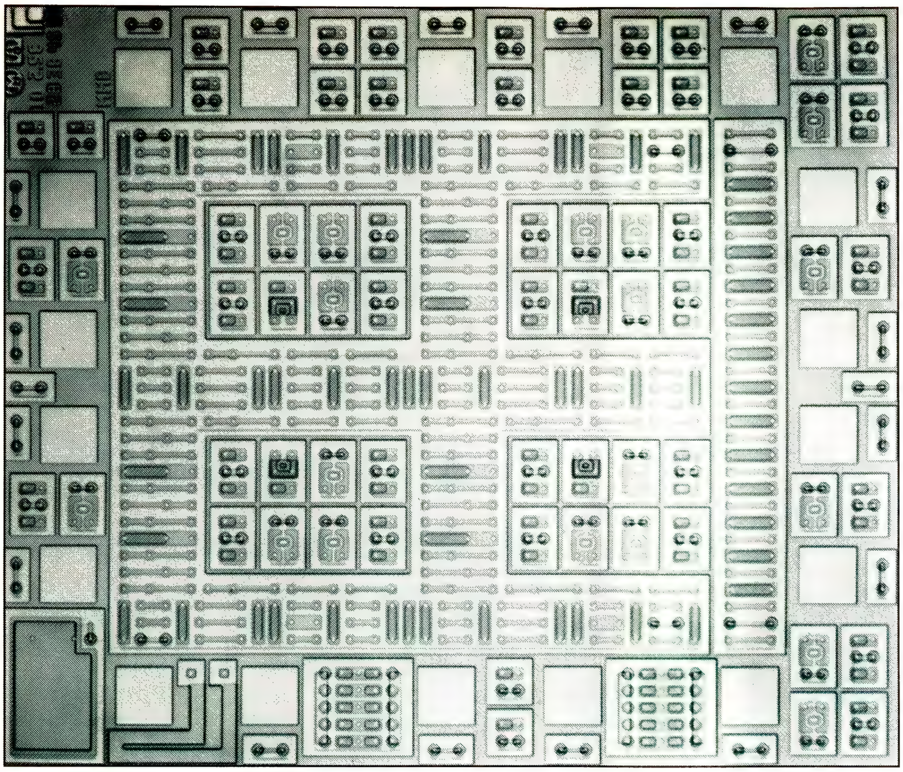
Linear Technology Inc., Burlington, Ont., has developed the Modula series of bipolar-based analog arrays, which organizes analog components into a set of building blocks. Each block contains varying mixes of standard and Schottky clamped npn transistors, double-collector lateral pnp transistors, multiple-collector pnp transistors, and base-diffused resistors of various values, as well as large npn transistors, low-noise npn transistors, zener diodes, junction capacitors, and pinch resistors on the periphery. Also offered is a library of predefined analog subcircuits, including op amps, comparators, video amps, timers, balanced modulators, bandgap references, and voltage controlled oscillators.

Taking the concept one step further, the Microcircuits Division of VTC Inc., Minneapolis, developed the VL1000 bipolar cell library, which contains a wide variety of predesigned analog, digital, and memory functions. Using it, the system designer can mix on one chip such analog functions as amplifiers, comparators, DACs, and references with such digital functions as gates, flip-flops, decoders, and various random-access and read-only memory blocks. Also included is a component library for custom cell design. On the digital side, clock rates up to 60 MHz are possible. Amplifier bandwidth is 200 MHz.

A much tougher proposition has been to automate analog design using CMOS technology. This is because CMOS is much more sensitive to parasitic effects than is bipolar due to the difference in impedance of the CMOS devices. So in analog arrays, the iterative simulation procedures used after cells or gates are placed and routed must be much more precise than for bipolar arrays. Still, a number of companies has succeeded in developing semicustom array methodologies using CMOS.

At International Microelectronic Products Inc., San Jose, a 3-μm CMOS standard-cell approach makes use of two types of analog cells. One consists of basic analog building blocks with predefined electrical and topological characteristics, such as op amps, voltage references, and comparators. The other consists of variable value elements, such as resistors and capacitors, whose properties can be adjusted for different design environments. A unique aspect of this design is the interconnection methodology, which incorporates separate channels between rows for analog and digital logic interconnection.

In development at Telmos Inc., Sunnyvale, is the TMG6000 series silicon-gate CMOS semicustom arrays, containing both analog and digital building-block macrocells. They are intended to implement systems requiring digital-to-analog and analog-to-digital conversion and precision analog processing and interfacing. The integrated series of gate arrays has matrixes of transistor pairs and dedicated flip-flops designed for high-speed digital logic interspersed with analog circuit elements. Among these are p- and n-channel transistor pairs matched for analog applications, MOS capacitors, npn common-collector transistors, zener diodes, high-value p-channel resistors, and precision poly resistors.



**5. LINEAR MACROCHIP.** Using predefined macrocells, Ferranti Interdesign's gridded bipolar linear array allows design of a range of customized macrochip circuits.

And from Silicon Systems Inc., Tustin, Calif., comes the Dynamic Analog Standard Cell, which uses CMOS technology and switched-capacitor techniques for circuits that combine analog and digital circuitry. One of the most general-purpose cells in the cell catalog is the switched-capacitor amplifier, which incorporates a folded-cascode input stage to increase bandwidth and a standard inverting output stage with capacitive feedback for compensation.

When used in combination with another building block, the capacitor array, virtually any switch configuration can be realized. Another important element is the differential multiplying DAC that, when used with other cells in the library, can provide almost any ADC configuration. It is also useful for performing digitally controlled analog multiplication needed for such functions as modulation or gain control. Other cell elements include input and output switches, gain blocks, and voltage comparators. Also included in the cell library are such classical analog functions as op amps, op-amp buffers, RC oscillators, bias generators, and supply dividers.

## GOING FOR THE PRO

Two companies—Analog Design Tools Inc., Menlo Park, Calif., and Valid Logic Systems Inc., San Jose—are aiming at the professional analog-circuit designer with a detailed knowledge of analog functions whose job is the development of full-custom implementations. Analog Design's offering is called the Analog Workbench, a turnkey stand-alone work station complete with 32-bit central processing unit, mass storage, display, and comprehensive design software. It comes with several circuit-element libraries, each containing models of such commonly used devices as bipolar transistors, JFETs, MOS FETs, and diodes. Other software includes an editing program for drawing and modifying schematics, simulation programs that emulate test-instrument operation, the user library module, and the parametric-modeling module.

Even though they may incorporate some analog-design aids, most CAD work stations have been geared to the design of digital logic, says Analog Design Tools president Charles B. Miller. "The function of a digital-circuit work station is to create and verify a complex roadmap of traces connecting thousands of circuit elements. An advanced analog circuit may have only 30 to 40 such elements. But each of those elements requires much more detailed characterization, with as many as 42 parameters for a single transistor. And where a digital work station simulates just one test instrument, analog engineers need a variety."

To provide the necessary tools, the workbench uses a menu-driven scheme that follows the workflow of the typical analog design process. For example, selecting Transistor from the circuit-element menu displays a listing of transistors available for use in the circuit. Once a design is complete, probes can be placed on the complete circuit designs in software for connection to a variety of test instruments, all simulated by the work-station software. After the circuit is drawn, the probes placed, and instruments selected, the workbench program performs the appropriate tests and displays the results on the screen. Three test setups are provided: a time-domain configuration with multichannel function generator and multichannel oscilloscope, a frequency-domain setup with sweeper and multichannel network analyzer, and a dc setup, with a dc multimeter.

The user library module enables the user to modify devices already in the workbench's 150-device library or to enter new devices at his own choosing, while the parametric plotting module assesses the effects on device performance of variations in parameter values, allowing the engineer to optimize circuit design. The software is being adapted to a variety of other work stations, says Miller, including Hewlett-Packard's HP9000 series 300 engineering work stations, the Sun Microsystems model 2/120, and Apollo Computer's Domain family of engineering work stations.

In the same vein, Valid Logic Systems recently introduced a CAD work station called the Analog Designer for engineers designing analog boards and circuits. In addition to a set of software that allows schematic entry and design validation, the unit also includes software emulations of the same instruments an engineer would expect on a well-equipped lab bench, including a digital voltmeter, an oscilloscope, a network analyzer, and a function generator.

In a typical design session, a schematic is created using Valid's graphics editor, which, in addition to a digital-logic cell library, contains a full set of analog components such as operational amplifiers, ADCs, DACs, switches, multiplexers, and discrete components. Once a schematic has been entered, it is then analyzed using the analog-design instruments contained in the software.

Companies that wish to remain in the analog business will have to develop semicustom linear arrays and make available design tools that simplify the analog design process, says Raytheon's Parsin. "Such methodologies are necessary if we are to continue to expand the market at a healthy growth rate. Neither traditional design techniques nor traditional analog circuits will disappear with the emergence of new alternatives." Indeed, he says, as analog circuits become more complex and greater numbers of systems designers get involved in the technology, such tools will have a synergistic effect on the sales of standard linear products. ☐

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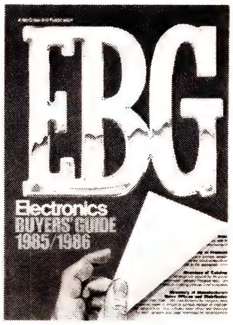

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# A BIPOLAR PROCESS THAT'S REPELLING CMOS

## TI'S SPEEDY IMPACT X USES TRENCH ISOLATION TO BUILD DENSER CHIPS

Just as the technology pendulum appears to be swinging toward low-power high-density CMOS processes, along comes a fabrication technique that can give bipolar processes new life. Developed by chip designers at Texas Instruments Inc., Impact X can triple the packing density, boost the speed and reliability, and halve the power consumption of the next generation of bipolar digital integrated circuits. The process won't derail CMOS development, but its high speed and its low power requirement will give designers some options among large-scale-integration and very large-scale-integration chips for future digital systems.

Impact X has another advantage. It enables process engineers to improve yield and manufacturability because the use of trench isolation eliminates two masking steps. And the limits to shrinking device sizes are less immediate with Impact X technology than with CMOS.

*Quadrupling the density of other bipolar processes*

The TI process already boasts the same 1.5-$\mu$m feature sizes of other advanced semiconductor technologies, but it relies on innovative trench-isolation rather than oxide-isolation techniques. A trench is a groove 1.5 to 2 $\mu$m wide that is cut into a silicon die to a depth of about 8 $\mu$m. It extends through the epitaxial layer and well into the substrate (Fig. 1). In addition to isolating active devices, the trench allows designers to reduce the pitch—the distance between individual transistor emitters. Conventional bipolar processes require about 20 $\mu$m of pitch; Impact X requires only 6 to 7 $\mu$m. With that pitch, about three times as many transistors can fit in the same area as a nontrench bipolar chip while maintaining the same 1.5-$\mu$m feature size. In this manner, Impact X technology as much as quadruples the packing density of other bipolar processes.

Closer packing, in turn, reduces the length of lead interconnection between devices. This means faster circuits, because roughly half of the propagation delay in logic elements is due to lead capacitance. A shorter interconnection has less capacitance associated with it.

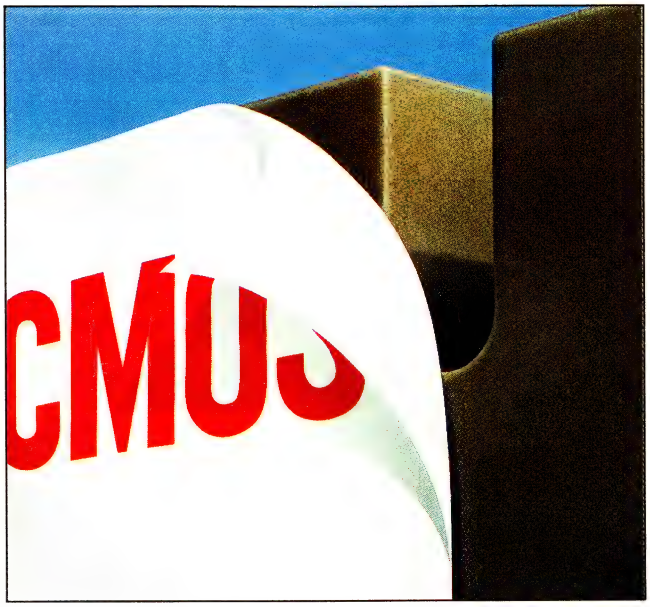
Performance is also boosted by reducing the depth of the base and emitter junctions. The base junction is about half as deep as in the original Impact process; the emitter junction is about one third as deep. Although junction depth is shallower, junction doping levels are greater than in earlier processes. The effect of increased doping is to reduce the series resistance between the base contact and emitter ($R_B$). This is a speed-enhancing technique in certain classes of transistors. Overall, a shallower junction in a bipolar transistor results in a higher operating frequency ($f_t$), and hence increased switching speed.

TECHNOLOGY TO WATCH *is a regular feature of* Electronics *that provides readers with exclusive, in-depth reports on important technical innovations from companies around the world. It covers significant technology, processes, and developments incorporated in major new products.*

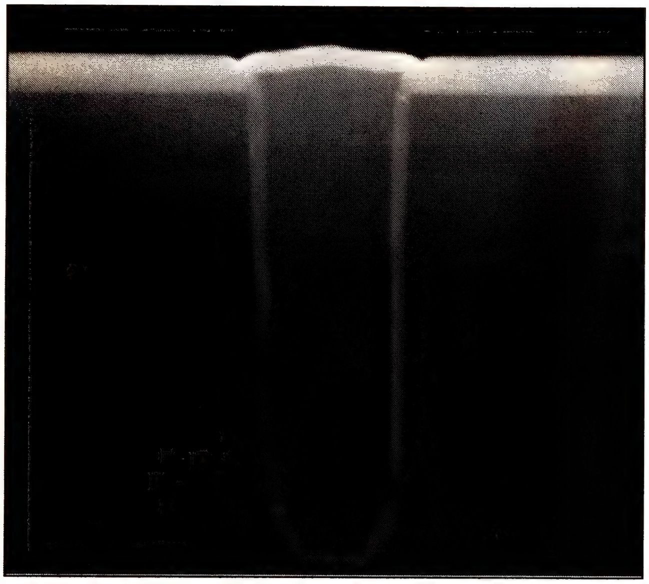
Only with shallower junctions can polysilicon emitters profitably be used for transistors. Polysilicon emitters are no strangers to discrete microwave transistors, but until now they have not been seen in digital logic devices. Experiments show that a polysilicon emitter imparts a higher gain (beta or $h_{FE}$) to a given transistor than conventional processing does. And high-gain devices lower the amount of power the IC needs to operate, which makes for a cooler chip. As most designers know, power dissipation (heat) and device reliability are intertwined in an IC technology. With less dissipation in each device, Impact X chips can offer higher reliability than competitive parts. In fact, Impact X chips, though they consume less power, are denser than their predecessors. This means that digital systems can be constructed with fewer ICs, giving an additional boost to system reliability.

Impact X's small geometry and high performance suit it for bipolar LSI and VLSI digital circuits. TI intends to use the process exclusively to build its next-generation 32-bit microprocessor chip set, a 64-K programmable read-only memory, and a 10-ns programmable logic array, and to work Impact X into its high-speed 888 emitter-coupled-logic family.

ECL functions are certain to be a primary beneficiary of this processing method. Impact X is of particular value to ECL RAM technology, which finds itself in a speed/power-product dilemma: the chips are vital in high-speed memory applications, but exact a high power-consumption premium. Impact X gives designers flexibility in tailoring them for speed/power-product performance. For example, it is possible to keep the same speed (15 ns) while halving the power to 0.5 W (table). Or the designer can choose to double present speeds without increasing power consumption.



Impact X processing could open up digital-systems opportunities beyond what's been predicted for bipolar technology. In bus-oriented computer architectures, for example, bipolar's greater current-driving capability gives it a decided advantage over CMOS technology. Although CMOS has the upper hand in regular logic structures with short interconnections—memories and multipliers are two examples—bipolar is a better choice at the periphery of LSI and VLSI chips. Here it is better able to handle



**1. DIGGING TRENCHES.** The isolating trench of Impact X (shown here in microphotograph) permits packing many more bipolar transistors in a given silicon area than conventional oxide isolation.

*IMPACT SHOWS STEADY PROGRESS*

| Circuit | Impact | Impact X |
|---|---|---|
| Standard TTL gate | 5 ns at 1 mW | 5 ns at 0.5 mW |
| Schottky-transistor-logic gate | 1.5 ns at 0.1 mW | 0.8 ns at 0.1 mW |
| Emitter-coupled-logic gate | 500 ps at 5 mW | 200 ps at 5 mW |
| 4-K RAM | 15 ns at 1 W | 6 ns at 1 W |

the capacitive-load environment of bused systems.

Although it incorporates numerous new process-design innovations, Impact X is not a brand-new technology; it is an enhanced version of an Impact technology created about three years ago. All versions of Impact technology—a third is called Impact S—use 1.5- to 2-μm feature sizes. And with each succeeding generation, pitch diameters have been coming down, yielding significant gains in packing density (chart, below). With the present 4-μm metal pitch rules, packing density is twice that of the previous generation. Projections for 1987 and 1988 call for feature sizes of about 1 μm and a further reduction in the metal pitch dimension to 2.5 μm. This will kick off another round of density increases and a further reduction in internal propagation delays.

In the Impact X process, a buried layer of n+ material is deposited over a standard p-type substrate in a conventional manner (Fig. 2a). A thin epitaxial layer is then grown. Narrow, deep trenches (1.5 to 2 μm wide by 8 μm deep) are formed in the silicon all the way through the buried layer to isolate one transistor from another. A channel-stopper implant of p+ material is inserted at the bottom of each trench wall.

## SPECIAL PROCESSING

A reactive ion-etch machine provides the special processing for high-aspect-ratio (5 : 1), straight-walled trenches. The trench walls are coated with an oxide and refilled with poly material. To prevent inversion and leakage at the oxide interface with the lightly doped substrate, the channel stopper is used. A field-protective oxide is deposited over the top of each trench and, through the oxide, circuit elements are formed.

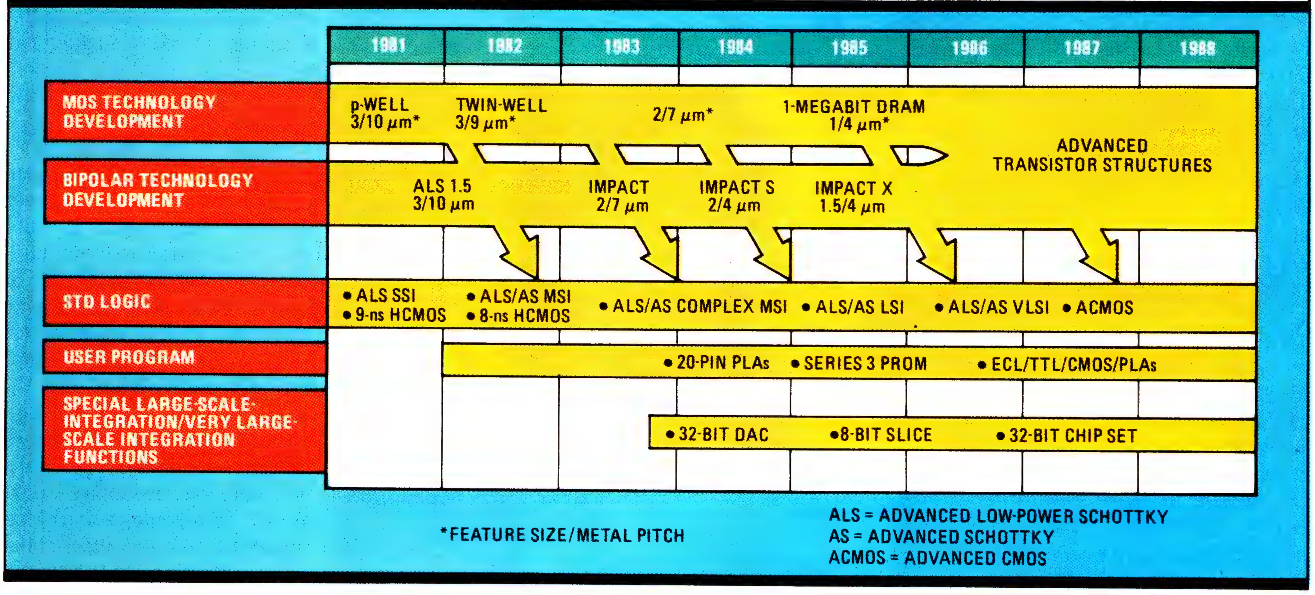
The photomasking operations that form the intrinsic and extrinsic base regions of transistors (Fig. 2b) involve no new technology; the technique is carried over from earlier Impact processing. The composed photoresist process permits close packing of components within a given isolation region by the self-alignment of the mask to the composing scheme.

After the formation of the p regions or transistor bases, a deep collector is formed and poly is applied to the emitter contact areas (Fig. 2c). The poly is heavily doped n+ and forms a contact with the shallow emitter region. This is necessary to prevent the metalization from affecting the characteristics of the underlying transistor.

TI uses the same metalization for Impact X as it used in previous bipolar processes—platinum silicide, titanium-tungsten, and aluminum on the top. Platinum and tungsten act as a barrier that prevents aluminum from diffusing into the silicon and destroying the shallow junction. A copper-aluminum combination is sometimes used to provide a higher current-density conductor, which prevents the effects of electromigration. CuAl offers a more reliable metalization scheme than aluminum alone in devices handling high currents.

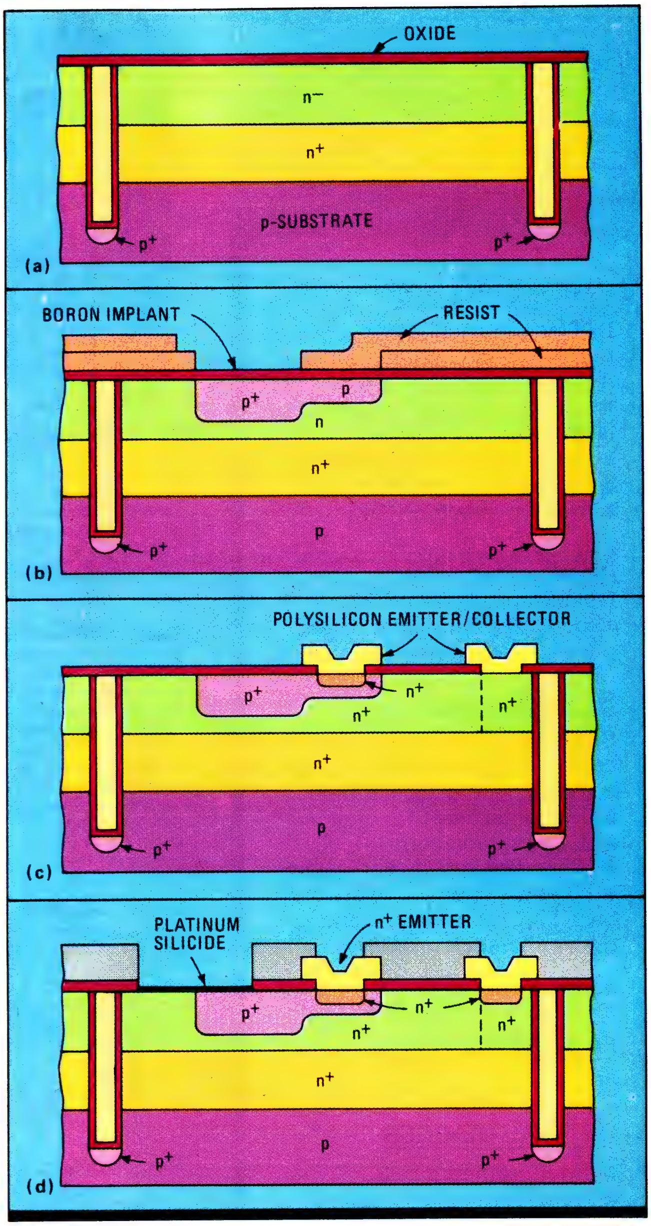
The final step of the Impact X process (Fig. 2d) is the formation of emitter and collector contacts and the deposition

*EVOLUTION OF BIPOLAR AND MOS TECHNOLOGIES*



*FEATURE SIZE/METAL PITCH

ALS = ADVANCED LOW-POWER SCHOTTKY
AS = ADVANCED SCHOTTKY
ACMOS = ADVANCED CMOS



**2. MAKING AN IMPACT.** Impact X begins with buried-layer deposition and trench formation (a). A composed photoresist process forms the bases (b). Emitter structure (c), contact patterning, and surface passivation (d) complete the process.

of a surface passivating substance to protect the device.

Because of the unique fabrication methods employed, Impact X devices exhibit an extremely flat or planar surface. In effect, the first- and second-level metalization layers of a chip do not have the type of step changes found in chips fabricated with conventional processing methods. Whenever a metalization step occurs, the metal thins out at the step, and designers must derate the metal's current-carrying capability in that area. No such derating is necessary in Impact X because the surface's extreme flatness eliminates step changes.

This planarization process also reduces the capacitance of the second-level-metal interconnection by widening the space between the first and second layers of metal. This reduces the capacitance between the two levels and improves switching performance.

In addition to the obvious density and performance benefits it brings to IC design technology, Impact X is allowing process engineers to break new ground in the basic processing methods of chip fabrication. TI engineers are combining plasma-deposition processes with reactive ion-etch removal in new and different ways to improve yield and manufacturability, as well. The use of trench isolation is noteworthy not only because it improves packing density but also because it eliminates two masking steps in bipolar fabrication. Fewer masking steps translates into higher device yield, so the time is fast approaching when complex ICs will be available at a reasonable price.

Both CMOS and bipolar technologies are scaled to small feature sizes in the range of 1.5 to 3 $\mu$m. But a problem could be looming for CMOS as chip designers attempt to scale to 1 $\mu$m and below. This is due to short-channel effects in MOS structures as well as to the reliability issues surrounding techniques for dealing with hot electrons. Chip designers will likely overcome such semiconductor barriers, but for the short term they pose limitations.

Bipolar technology, on the other hand, faces no immediate scaling limitations and probably will not until feature sizes fall into the 0.5-$\mu$m range. This is still some years off, however. Therefore, designers can expect continued performance improvement from bipolar devices while such gains in CMOS technology arrive more slowly. ☐

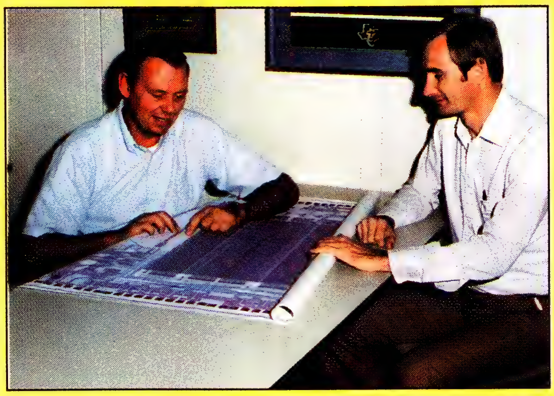
## THREE-WAY EFFORT AT TEXAS INSTRUMENTS SCORES WITH IMPACT

**You could call** Texas Instruments Inc.'s development team for the Impact X process a triple-play combination: it has produced three Impact generations as well as made major contributions to other bipolar products. At one end is Deems (Randy) Hollingsworth, product development manager of TI's bipolar development branch in Houston, who managed and scheduled the process development. A graduate of North Carolina State University with an MSEE, Hollingsworth has spent his entire seven-year career at TI.

At the other end is Robert A. Stehlin, manager of new products for the technology department within the company's Semiconductor Group in Dallas. Stehlin looked at the Impact X technology in terms of products that would meet market needs. With 12 patents to his credit, Stehlin holds a BSEE from the University of Cincinnati and advanced degrees from Southern Methodist University.

In the middle is David B. Spratt, manager of advanced bipolar process development in Dallas. Of Spratt's 20 years of professional experience, 17 have been at TI and nine have been in bipolar process development. Spratt, who holds a BSEE from the University of Texas and did graduate work at Lehigh University, served as a liaison, translating and coordinating between Hollingsworth's process developers and Stehlin's product developers.

Convinced that bipolar still has plenty of performance margin to be exploited, the team is already thinking about the next generation. But they haven't decided if they'll call it Impact Y "or whatever," says Hollingsworth.



**IN CONFERENCE.** Stehlin (left) and Spratt, along with Hollingsworth (not shown), were responsible for Impact.

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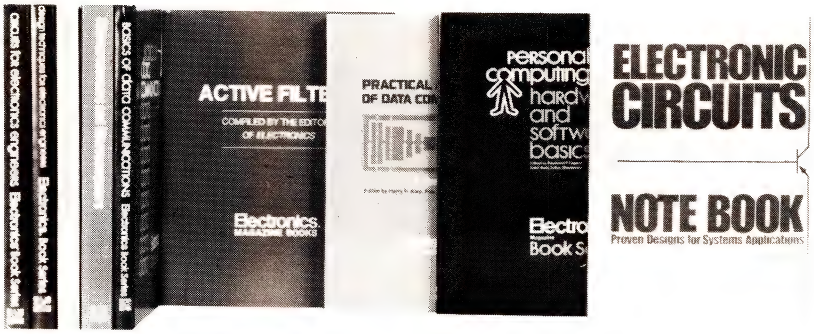

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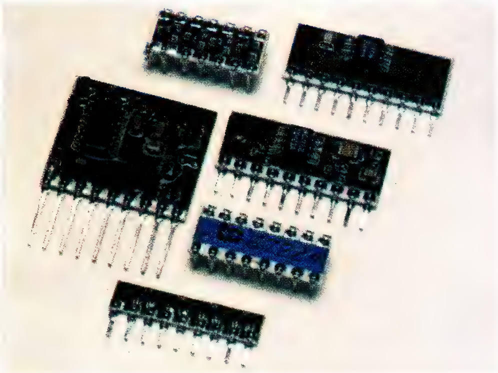

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# THE BIG NEWS AT ISSCC: DIGITAL SIGNAL PROCESSORS

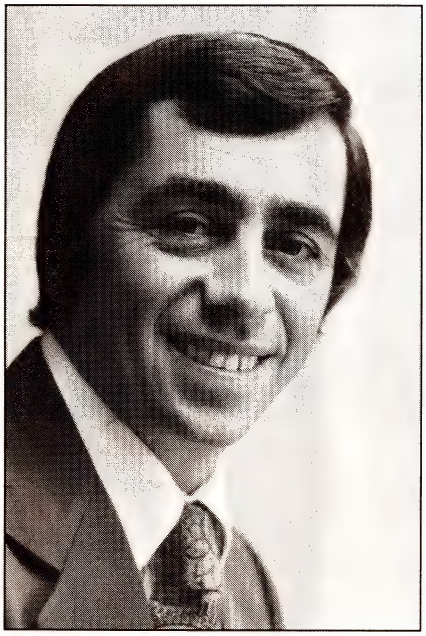
## A TRIO OF 32-BIT MODELS WILL STAND OUT AMONG 19 DESIGNS

*by Bernard Conrad Cole*

Designers get together every February at the International Solid-State Circuits Conference to preview the major trends in integrated-circuit technology for the next 12 months. Next year's ISSCC will be no different. The big news in Anaheim, Calif., on Feb. 19-21 will be the emergence of digital signal processing as a mainstream circuit technology, with chips comparable in complexity and functionality to general-purpose microprocessors. Advances in other solid-state technologies scheduled for discussion at ISSCC, however, will be evolutionary, a departure from recent conferences.

"Rather than describing quantum jumps forward, the majority of the upcoming ISSCC papers will focus on incremental improvements," says 1986 conference chairman Alan Grebene, president of Micro Linear Corp., San Jose, Calif. "While there are significant improvements in particular areas, overall the curve of technological advancement is less steep than in previous years," he says. "Generally, this meeting represents a period of retrenchment, a pause during which circuit designers and engineers have taken the significant breakthroughs of previous years in process and device technology and methodically applied them to their designs."

The attention devoted to digital signal processing is impressive, however. Digital signal processing is the focus of 19 papers (out of a total of 82) and four sessions. Most impressive are the three 32-bit digital signal processors from Philips Research Laboratories, Eindhoven, the Netherlands; NEC, Kawasaki, Japan; and Texas Instruments, Bedford, England. This emphasis compares with just the five papers and single session devoted to general-purpose central processing units and coprocessors.



**NO LEAPS.** Grebene says the ISSCC program features incremental improvements.

The Philips design has a 125-ns instruction cycle and throughput of 8 million instructions per second. Fabricated using a 2-μm CMOS process, it contains two 16-bit data buses, executes a 40-bit orthogonal instruction set, and supports up to six concurrent arithmetic and data-move operations in each instruction. NEC's design combines a 32-by-32-bit floating-point parallel multiplier and a 55-bit floating-point arithmetic logic unit on the same chip. Fabricated with a 1.5-μm CMOS process, it contains 370,000 transistors and has an instruction-execution cycle time of 150 ns. The TI circuit is a graphics-system processor that also contains instruction cache memory, a cathode-ray-tube controller, data random-access memory, and host-interface logic. It is fabricated in 1.5-μm CMOS, contains about 200,000 transistors, and achieves throughput up to 6 mips.

To be discussed in the same session is a digital audio filter using 6-μm n-MOS processing. From Interuniversity Microelectronics Center, Leuven, Belgium, it contains an offset filter, a graphic equalizer, and a scratch filter, and features a signal-to-noise ratio of 100 dB. The final paper in the session is on a pattern-matching processor array with defect tolerance. It is from Nippon Telegraph & Telephone Corp.'s Musashino Electrical Communications Laboratory in Japan and is a 16-bit processor with sorter logic and a 32-K dictionary RAM. Developed for handprinted kanji character recognition, it contains 460,000 transistors, using 3-μm double-layer metal CMOS.

Two signal processors—one from the University of Michigan and the other from Toshiba Corp., Kawasaki—will also be discussed in the session on sensors and interface elements. Designed to sense neural signals, the Michigan offering combines a 10-channel microelectrode array on the same chip as a signal processor and self-testing logic. Fabricated with a 6-μm CMOS process, it consumes only 5 mW of power. The Toshiba design is a 32-bit signal processor designed with an on-chip writable control store for imaging applications. It is built with a 1.2-μm n-well CMOS double-layer metal process and contains 170,000 transistors. Toshiba says it can process a 1,024-point complex floating-point transform in less than 1 ms. Power dissipation is 750 mW at 5 V.

In the same session are three designs for charge-coupled devices: they are a 500-by-600-element smear-suppressing imager from Matsushita Electronics Corp., Osaka, and a 1,280-by-970-pixel interline-transfer image sensor from NEC, as well as a bipolar, junction-isolated, 32-channel, flat-panel-display controller, from Hitachi Research Labs in Tokyo, with 150-V push-pull drivers operating at 7 MHz.

Special-purpose processors and controllers also get their turn in the limelight. SDA Systems Inc. and National Semiconductor Corp., both of Santa Clara, Calif., are to describe their 32-bit digital signal processor for motor control. Using a 3-μm n-MOS process that dissipates only 250 mW, the designers have come up with a 0.5- to 1.5-μs instruction-execution-cycle time. In the same session will be a 25-Mb/s CMOS disk data controller from National Semiconductor, a 1.5-Mb/s 128-channel pipeline multiplexer from NTT's Musashino Electrical Communications Laboratory in Japan, and a two-chip, 3.5-μm n-MOS chip set from Digital Equipment Corp. in Hudson, Mass., designed for simultaneous display of text at 20,000 characters per second and graphics at 8 million pixels per second.

Four more digital signal-processor designs are to be included at the session on video- and image-signal processing. From the NTT Atsugi Electrical Communication Laboratories in

Kanagawa, Japan, will come two 14.3-MHz digital signal processors, designed to convert composite video signals into chrominance and luminance components, fabricated with 2-μm CMOS. Aimed at similar applications will be a design from Mitsubishi Electric Corp., Itami, Japan, that incorporates adaptive filtering and combines an 8-bit pipelined signal processor, a two-line cache-store RAM, and 18-K of serial memory. The CMOS circuit, with its 2-μm design rules, can operate at 17.7 MHz, dissipating only 450 mW. A third signal processor from CNET-CNS, Meylan, France, is a two-chip implementation of a composite red-green-blue decoder using oversampling filters and color look-up tables. Fabricated with 3-μm n-MOS, it features 27-MHz clock speeds and a 900-mW power dissipation.

In the same session will be a microprogrammable real-time image processor from Matsushita Electric Industrial Co., Osaka, Japan, with a 20-ns cycle time. It is built with a self-aligned bipolar process and a two-dimensional 22-MHz digital filter containing on-chip, first-in first-out buffer memory from Siemens AG, fabricated in 2-μm double-well CMOS.

## A MICRO-MAINFRAME IN SIX CHIPS

Less numerous this year will be the general-purpose microprocessor and coprocessor designs. Five in all, they make up for their lack of numbers with innovative design and high levels of integration. For example, there is a 32-bit single-chip microprocessor from IBM Corp.'s Watson Research Center in Yorktown Heights, N. Y., that incorporates 102 mainframe instructions and supports emulation of the rest of the instruction set. A CMOS design, it is reported to contain almost 2 million transistors on a 10-by-10-mm chip with power dissipation of only 3 W, operating at a 16-MHz clock rate. From Sperry Corp., Eagan, Minn., will come a six-chip, 36/72-bit, micro-mainframe set with a mainframe-compatible instruction subset. Containing 786,000 transistors and fabricated using a 1.2-μm double-layer metal CMOS process, the design allows operation over a range from 0.4 to 1.5 mips.

*IBM incorporates 102 mainframe instructions in a 32-bit processor*

IBM's Los Gatos, Calif., operation will describe a 32-bit CPU fabricated using a 2-μm process with an eight-level cascode ECL circuit implementation. Executing a subset of a mainframe instruction set, the 14-by-16-mm chip dissipates 16 W.

In an extension of earlier work in this area, researchers from the University of California, Berkeley, will describe a 32-bit microprocessor designed for direct execution of the high-level language Smalltalk. The CPU, built with a 4-μm n-MOS process, has an instruction-execution cycle time of 400 ns. Also to be discussed will be a 64-bit floating-point design from Hewlett-Packard Co. in Cupertino, Calif., consisting of three n-MOS chips with 1.5-μm design rules. Consisting of an adder, a modified Wallace tree multiplier, and a combinatorial divider, the devices operate at 490, 660, and 1,610 ns, respectively.

Almost as ubiquitous and numerous as the various general-purpose and digital signal processors will be the 21 analog circuits to be described in four sessions. Most impressive in terms of complexity and sophistication are the six designs to be included in the session on voice-band telecommunications ICs.

For example, from Oki Electric Industry Co., Tokyo, there will be a single-chip analog front end for 1,200- and 2,400-b/s modems. Fabricated using a 5-μm CMOS process, the 6.5-by-6.37-mm chip contains both analog-to-digital and digital-to-analog converters, microprocessor interface logic, 50-pole filters and equalization circuitry, tone generators, and a call-progress detection filter.

Researchers from TRT, in the Paris suburb of Le Plessis Robinson, and Thomson Semiconducteurs, in Grenoble, France, will describe a three-chip set that is full duplex with an analog front end, for split-band and echo-canceling modems. It is made with 4-μm CMOS. The chip set performs both analog-to-digital and digital-to-analog conversion, analog subtraction of replicated echo signals, filtering, automatic gain control, and analog carrier detection for split-band modems up to 2,400 baud and for echo-canceling modems up to 16,800 baud.

Equally impressive will be the monolithic data-access and line interface IC for modems and private-branch-exchange trunk lines from Harris Corp.'s Semiconductor Products Division, Melbourne, Fla. Fabricated using a 200-V bipolar process, the circuit incorporates on-chip radio-frequency modulation to isolate capacitively up to 1,500 V on the line and uses electrothermal techniques to transfer supervisory information. In the same session will be a 90-V switching-regulator and lightning-protector chip set from AT&T Bell Laboratories, North Andover, Mass.; a 15-bit interpolative converter chip set from Hitachi Central Research Laboratory, Tokyo; and a multistage delta-sigma modulator using two interleaved single integration loops from NTT's Atsugi Electrical Communication Laboratories, Kanagawa.

In the session on analog processors, four sophisticated special-purpose designs will be described: two bipolar chips (a 10-Mb/s read-data processor and a 15-Mb/s data-separator and write-precompensation circuit for Winchester disk drives) from Silicon Systems Inc., Nevada City, Calif.; a 2-V amplitude linear phase-locked loop CMOS design from National Semiconductor; and a 14.5-GHz hybrid microwave distributed amplifier, for converting single-ended to balanced outputs, from the University of Wisconsin, Madison.

The session dedicated to converter designs will describe a

*SOME KEY TOPICS AND PLAYERS AT ISSCC*

| Analog technology | Signal processors | General-purpose processors | Semicustom ICs and arrays | Memories |
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CMOS slope adaptive delta modulator configuration from the Massachusetts Institute of Technology; an 80-MHz 8-bit CMOS DAC from Mitsubishi Electric Corp., Hyogo, Japan; a 100-b/s CMOS video DAC with on-board shift registers and color table from Digital Equipment Corp.; an 8-bit oxide-isolated ADC from Hewlett-Packard, Santa Clara, with a full-power bandwidth of 250 mHz; a 120-kHz 11-bit sigma-delta ADC from Siemens, Munich; and a CMOS ADC from Harris Semiconductor incorporating a unique digital error-correction scheme to increase the speed of successive-approximation operations from 12 to 7 µs.

## WHERE 'SPARKS WILL FLY' AT ISSCC

**An annual** highlight of the International Solid-State Circuits Conference is the "anything-goes" panel sessions. The 1986 ISSCC will include a full battery, featuring the views of industry specialists on such topics as architectures for future large-scale-integration digital signal-processor designs, practical limits of very large-scale-integration testers, and cost-performance tradeoffs in the design of 4- and 16-Mb dynamic random-access memories. Panels will also cover ultrahigh-speed static-RAM technologies, reduced-instruction-set computers, the integrated services digital network and the future of telecommunications VLSI, application-specific memories, and making the transition from 5-V to 3-V VLSI.

"If these are similar to previous years, sparks will fly," says 1986 ISSCC chairman Alan Grebene. "The participants usually take off the gloves, with many of the discussions becoming rather emotional and intense. Most of the issues to be discussed are still in a state of flux. As a result, the discussions at the ISSCC usually determine, or are at least indicative of, technology trends one or two years in the future. The panel discussions at the 1986 ISSCC will be no exception." *–B. C. C.*

On analog techniques, five papers are scheduled: a 50-fA input-current junction-isolated JFET operational amplifier from Analog Devices Inc., Wilmington, Mass.; a bipolar op amp with a noise resistance of less than 50 Ω and a 25-MHz thermally based root-mean-square-to-dc converter from Linear Technology Corp., Milpitas, Calif.; a junction-isolated CMOS analog controller featuring 500-V, 1-A, double-diffused MOS transistors from North American Philips Corp., Briarcliff Manor, N. Y.; and a quad CMOS single-supply op amp with rail-to-rail output from National Semiconductor.

Taking a back seat to analog circuitry and digital signal processing at the 1986 ISSCC is memory technology. Convention chairman Grebene says the technology appears to have leveled off at 1985 density levels. "The focus this year in memories in general is increasing speed, lowering power, and improving manufacturability," he says.

The one exception to this trend will be the 4-Mb dynamic RAM from TI. Using double-level CMOS technology based on a crosspoint trench-transistor cell, the chip measures 10 by 10 mm and is laid out 1 megaword by 4 bits with row and static column access times of 170 and 30 ns, respectively.

Also included are a 47-ns CMOS DRAM arranged as 64-K words by 4 bits from Mitsubishi; a 65-ns CMOS 1-Mb DRAM from Intel Corp., Hillsboro, Ore., that features a reduced failure rate; a 1-Mb CMOS DRAM from TI with a reconfigurable architecture designed specifically for testability; and a 1-megaword-by-1-bit CMOS DRAM from Toshiba Semiconductor Device Engineering Laboratory, Kawasaki, with a 50-µA standby current and a 56-ns access time.

*TI's 4-Mb DRAM uses trench-transistor cells and two-level CMOS*

In static RAMs, when measured in terms of significant improvements in speed, the accomplishments are not so modest. On the schedule are an 18-ns n-MOS design from Toshiba laid out as 8-K words by 9 bits; a 30-ns full CMOS SRAM with a divide word line that is 32 by 8 bits from Sony Corp., Kanagawa, Japan; a 15-ns clocked CMOS model from IBM in Yorktown Heights; two CMOS 64-K SRAMs with 13-ns access times from Motorola Inc.; a 3-ns 32-K bipolar SRAM from IBM's General Technology Division, Hopewell Junction, N. Y.; and a 13-ns 500-mW ECL version from Hitachi Ltd.'s Development Center in Tokyo.

In nonvolatile memories, the focus will be on innovative methods for reducing power and increasing speeds. Current offerings will include two from Advanced Micro Devices Inc., Sunnyvale, Calif.: a 1-Mb CMOS erasable programmable read-only memory that accesses in 150 ns and dissipates only 250 mW; a 30-ns, 128-K, fusible-link bipolar PROM; as well as a 70-ns 2-Mb mask ROM with a through-hole programmed memory-cell architecture from Toshiba. In the same session, a number of application-specific memory designs will be described, including a 500-MHz digital CMOS radio-frequency memory chip from Raytheon Co., Andover, Mass., featuring 8 Mb of RAM with shift registers; a dual-port, 65-ns, 64-K-by-4-bit DRAM with a 50-MHz serial output from Mostek Corp., Carrollton, Texas; and a 2-µm CMOS 32-bit-wide memory-management unit from Fairchild Semiconductor Corp., Palo Alto, featuring an on-board 40-K cache.

### CUSTOM AND STANDARD LOGIC

Two sessions will be devoted to high-speed custom and standard digital logic ICs. Among the papers in the session on optical data links will be a 50-Mb/s CMOS light-emitting-diode driver circuit from AT&T Bell Laboratories in Allentown, Pa., and a 50-Mb/s CMOS optical data-link receiver circuit from the labs' Reading, Pa., outpost; a 200-Mb/s bipolar fiber-optic data-link chip set from Plessey Research in England; and a 2-Gb/s n-MOS laser driver IC from AT&T Bell Laboratories in Holmdel, N. J.

Even more impressive will be the session on high-speed digital logic circuits. Included will be a 5.5-Gb/s bipolar 4 : 1 time-division multiplexer from Ruhr University, Bochum, West Germany; a 900-ps bipolar ECL 16-by-4-bit register file from Fairchild Research Center, Palo Alto; a family of bipolar CMOS ICs for use in 60-MHz digital signal processing from Hitachi's Research Laboratory, Ibaraki, Japan; a 3-GHz, 12-channel, optical-fiber multiplexer-demultiplexer chip set fabricated in 1-µm n-MOS from Anadigics Inc., Warren, N. J.; a 32-bit CMOS Wallace tree multiplier-accumulator from LSI Logic Corp., Palo Alto, featuring a 56-ns cycle time; and a 279-ps, 2.2-GHz, 4-by-4-bit multiplier and 3-bit counter circuit from Hitachi using Josephson-junction threshold logic.

Two sessions will be devoted to semicustom and reconfigurable logic arrays. Included in one session will be discussions of a two-level-metal n-well CMOS logic array with 1.6-µm features from NEC; a bipolar-CMOS field-programmable logic array from National Semiconductor; a bipolar four-level-metal ECL 18-K gate array with variable-sized cells from Mitsubishi; a 3,000-gate gallium arsenide array from NEC that is compatible with current-mode logic; and a 4,000-gate bipolar GaAs array from TI.

For the session on reconfigurable logic, the schedule now shows three papers. One will describe a 16-ns CMOS electrically erasable programmable logic array with a reprogrammable architecture from Lattice Semiconductor Corp., Beaverton, Ore.; an erasable programmable CMOS logic circuit with zero standby power from Altera Corp., Santa Clara; and a dynamically reconfigurable processor array chip from ITT Corp.'s Advanced Technology Center, Shelton, Conn. □

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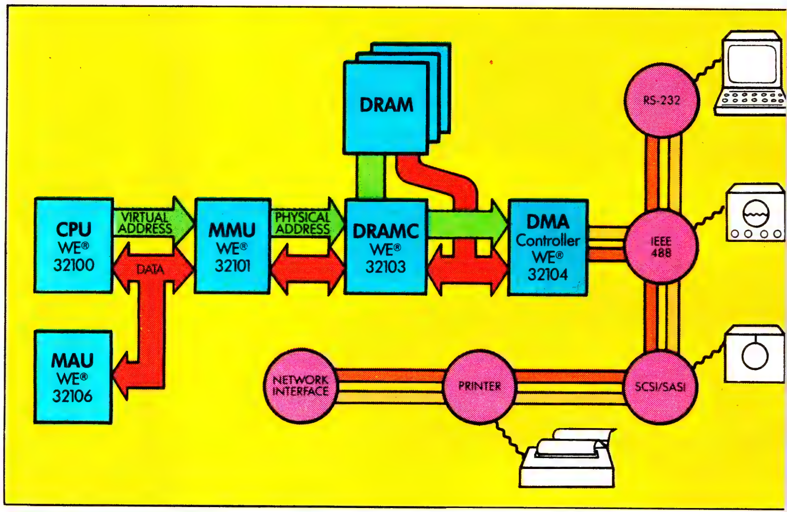

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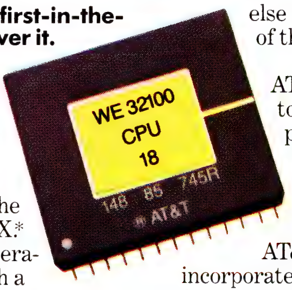

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PROBING THE NEWS

# DATA GENERAL'S STRATEGY TO RUN WITH THE LEADERS

## ITS GAME PLAN: TO BE A FULL-LINE SUPPLIER TO LARGER CUSTOMERS

*by Craig D. Rose*

**WESTBORO, MASS.**

In the old days at Data General Corp., so the story goes, a worried sales manager would brandish a harpoon and tell his salesmen the barb would wind up in his back unless they met their sales quotas. The harpoon still stands at an office in the minicomputer maker's corporate headquarters, a sprawling structure whose interior design theme remains sensory deprivation. There are other constants at the home of the hard-selling crew nicknamed "the bastards of Route 128": Edson de Castro still heads the company, and corporate barbs continue to be hurled at crosstown rival Digital Equipment Corp.

But despite these holdovers from the old days, a new kind of corporation has emerged. The rough-and-tumble Data General crowd has gotten new religion. Their scripture? That the computer industry's judgment day is near, niche companies are doomed, and the survivors will be a handful of full-system vendors with quality customers. Data General is determined to make that final cut.

So the company that made it big by selling "iron" and relying heavily on original-equipment manufacturers is racing to change its act. First came Data General's all-out thrust into the office market; later will come a plunge into industrial automation, a market that Data General estimates will grow more than 30% annually, as well as other efforts in the drive to become a full-line supplier of information-processing systems to Fortune 500 companies.

The overhaul began two years ago with Data General's move into integrated office systems by way of its CEO system. That product opened some important doors. But those doors could close if the company can't sell the entire range of products required by its customers.

The past year has not been an easy one, either for the company or its competitors. Data General's much ballyhooed portable computer, the Data General/One, failed to sell in volume. Worse, the company's overall performance fell significantly below that of some of its larger computer neighbors along Boston's technology belt. Though Data General's revenue for fiscal 1985 rose 6.7% to $1.23 billion, operating income plunged from $102.6 million in fiscal 1984 to $36.1 million. And in the most recent quarter, ended Sept. 28, income plummeted from $24.3 million to just $500,000.

Integrated office systems continued to be a bright spot, but the company took hard hits in its 16-bit and industrial OEM businesses. In June, it slashed its 18,000-member work force by laying off 1,300 people, and another 100 took voluntary layoffs. Exacerbating the bad times, Data General was caught short in the midst of a new industry product cycle until it made headlines in November with an extravagant multiproduct announcement [*Electronics*, Nov. 18, 1985, p. 24].

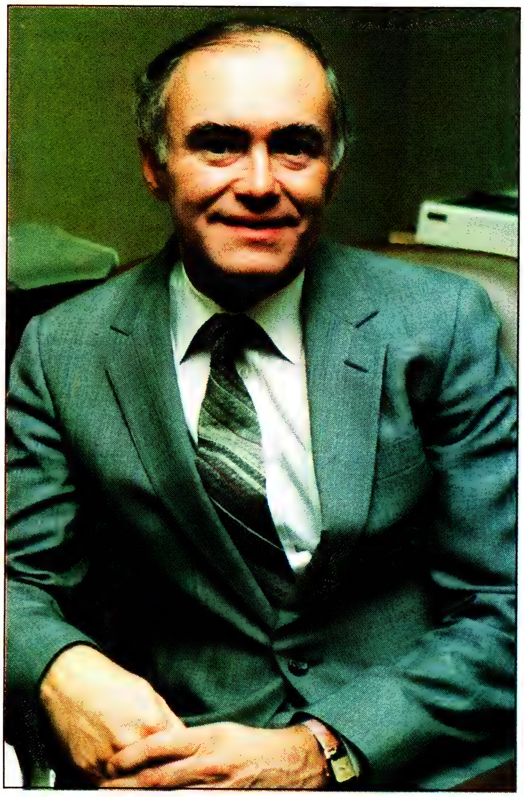
De Castro, in effect, shrugs off the 1985 performance. For one thing, he says, if performance is viewed over a two-year period—1984 was a strong year for the company—it averages out well. More important, he argues, focusing on the bottom line now is a mistake.

"I don't believe this is a time to really push profits," says the 47-year-old company founder. "That doesn't mean you can lose a lot of money—you have to turn a reasonable profit. But on the other hand, I don't think this is the time to try to return large profits. I think it's the time to get your stake in the ground and establish decent market share."

Data General put a big stake in the ground with the array of products announced in November. On the same day, the company unveiled new top-of-the-line superminicomputers (including a dual-processor model), a work station, a new low-end minicomputer, a distributed operating system complete with windowing features, and a software product that combined engineering and office-automation features. It also announced price cuts on existing products.

The MV 20000 Model 1 supermini drew the most attention. The machine can execute 5.5 million instructions per second, uses emitter-coupled-logic gate arrays extensively, and is priced about 30% below DEC's popular VAX 8600, generally pegged at 4-plus mips. Data General says that in a dual-processor configuration, the 20000 will execute 10 mips, and this version of the machine costs about the same as the 8600. The announcement gave Data General another set of price/performance numbers to boast about.

The impact reminded some of the time, four years ago, after Data Gen-



**GROWTH FIRST.** For de Castro, in today's economy, a bigger market share is more important than the bottom line.

eral fell behind in the development of a 32-bit supermini. The company was nearly written off at the time, recalls Marc Schulman, a vice president with Salomon Brothers Inc., New York. But then its Eagle zoomed in, setting new price/performance standards. Data General made a similar splash in 1983 when it introduced the MV 10000. That machine was very successful for the company, though it was not able to unseat the VAX-11/780 as the de facto standard at the time.

"The job in front of them now is easier than three years ago," says Schulman. "Three years ago, Data General had no presence at all in Fortune 500 accounts." Since then, he adds, it has built at least some image with the largest companies.

However, Data General's thrust comes at a time when many companies are trimming their capital-expenditure budgets, which might make for tougher sales. Three years ago, the economic climate was balmier, notes Stephen Smith, a vice president for Paine Webber Inc., New York. But in the current environment, "the doors are closing."

**WHERE ARE THEY?** The relatively limited presence of Data General among Fortune 500 accounts is apparent to George Colony, president of Forrester Research Inc., Cambridge, Mass. "We keep doing surveys on departmental computing and we don't find Data General," says Colony. "We did one on insurance and spoke to every Fortune 1,000 insurance company. And not one had Data General equipment."

Data General counters that its roster of Fortune 500 accounts is significantly larger than it used to be. In 1980, the company counted fewer than 10 Fortune 500 customers, says Robert Miller, senior vice president. Today, he says, the count is upward of 140 Fortune 500 or equivalent companies as end-user customers. "It may be approaching 200," says Miller.

There's no question that the scarcity of such customers hurt and undoubtedly contributed to the company's erratic performance over the past few years. "Let's face it, the guy who's farthest out suffers the most variation in velocity and acceleration," says Miller.

The struggle for the stable blue-chip business has largely been an effort to make a potential customer's short list of vendor candidates. "Once we get on the list, we've done well," says de Castro. Then, despite Data General's traditional price/performance emphasis, de Castro says the question is "not really dollars per mips, but do you have full Systems Network Architecture—because everyone has IBM—can you hook to a PBX, and can you connect with whatever their application happens to be."

The Data General hierarchy believes that only with this type of customer base can the company survive the consolidation that its prognosticators perceive as the future of the industry: by the year 2000, de Castro predicts, only six or seven computer companies will still be around. To prevail, he says, "The most important criterion will be breadth of product line." Other essentials are the ability to integrate with other vendors' equipment, broad distribution channels, and low-cost production.

**CEO IS SPEARHEAD.** For now, the company's leading product in selling to large accounts is CEO. This portion of the business evolved from experience with Data General's first word processor, AZ-Text, introduced in 1979, says Barbara Babcock, now director of software and systems in the Product Marketing Division. She was author of the company's first plan for selling into the office market.

Response to that machine, she says, soon convinced the company that the integrated office-systems market was potentially huge, without established leaders, and within its reach technologically. Development of CEO took two years. Then, the company faced considerable marketing problems.

The first was image. Data General was an OEM company not associated with office-automation products. So the company held seminars for the business community and ran its first TV commercials.

**REWORKED SALES FORCE.** It also proved necessary to make adjustments in the sales force. Data General's sales force was accustomed to OEM technical types who understood the language of bytes and boards. In the office-automation market, the customer just wanted to know about solutions. Retraining was in order and Data General also brought on people with experience in the market.

The first major CEO order came from the E. F. Hutton Group Inc., New York. Other wins were the U. S. Forest Service, Westinghouse, Texaco, and, more recently, Nynex.

Farther down the road, Data General anticipates growth of 30% to 40% a year in its office-automation business, which Miller terms "the next major productivity gain for U. S. industry and corporations worldwide. Data General has moved itself up to where it's in the third or fourth position on the [office automation or] data-processing side" when prospective purchasers put together a short list of vendor candidates.

But the lead that Data General built by arriving early with a technically strong product may be hard to maintain. The company held 20% of the installed office-automation software licenses in 1985, but its share is projected to drop to 19.3% next year, according to Dataquest Inc., the San Jose, Calif., market-research company (chart, p. 58). At the same time, Dataquest projects, DEC's market share will rise from 17% to 17.3%.

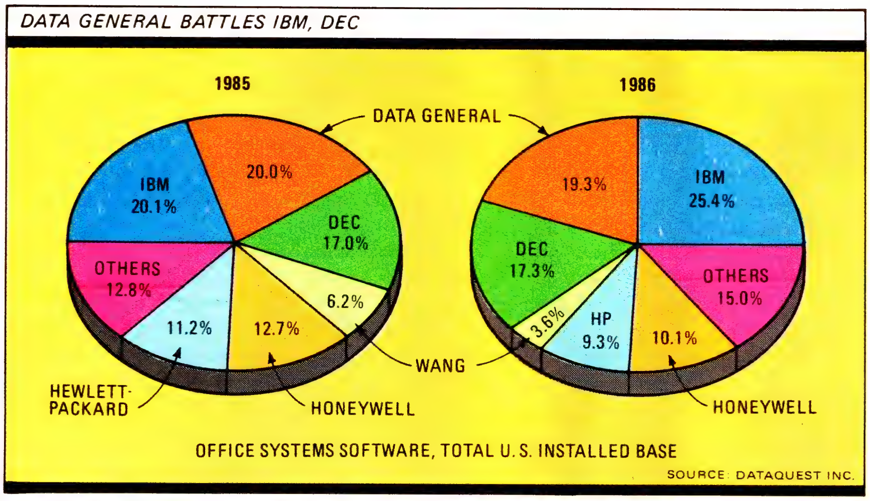
"What you want to do in this market is create grassroots demand, so it's important to have a large installed base," says Linda O'Keeffe, director of office systems services at Dataquest. But, she adds, Data General's software licenses tend to be implemented in smaller configurations than DEC's.

Data General counters with its own argument. In the first few years, says Babcock, at least 75% of CEO sales were new business, with the customer buying en-

**FAST TIMES.** Miller sees "a less crowded track out there for Data General to race on."

**SIMPLE DESIGNS.** West emphasizes lean architecture as a key Data General advantage.

*DATA GENERAL BATTLES IBM, DEC*



OFFICE SYSTEMS SOFTWARE, TOTAL U. S. INSTALLED BASE

SOURCE: DATAQUEST INC.

tire systems. DEC made most of its sales into an existing customer base, he says.

O'Keeffe agrees that the selling approaches of the two competitors are different: "DEC is selling office as a component of other things, whereas Data General has been selling office." She also predicts the market will grow more technically competitive as vendors integrate voice and text into their office systems over the next year.

If the technical competition does heat up, CEO, thought by many to be the best product of its kind, could come under performance pressure from more recently designed systems. "The problem is that the underlying technology is changing rapidly," says Jit Saxena, who was director of the software development group at Data General when CEO was developed. He is now president of Applix Inc., in Westboro. CEO was designed primarily for dumb terminals running off a minicomputer, not for the distributed environments that are state of the art.

Data General has already made some changes in CEO that tie in microcomputers to a limited extent. What's more, de Castro characterizes the market as a "fast-moving target" and recognizes that his company must provide new capabilities, new applications, and new hardware. But there seems to be little motivation for a major overhaul of the product at this time.

**SPREADING OUT.** Meanwhile, Data General will attempt to parlay its office-automation success into other types of business. "Our primary strategy is to get a presence through the commercial side, get established as a supplier of choice to the Fortune 500, and then market our technical products competitively for their new application areas," says Miller. "Clearly, our penetration approach has been through our [office automation] products and our IBM compatibles."

One IBM compatible that failed to penetrate was the Data General/One. The portable was launched a year ago when many were touting the laptop market as the hottest new game in personal computers. Although the Data General/One packed more functionality and battery life into a 10-lb package than any other machine, its liquid-crystal display is difficult for the user to read.

Three price cuts and minor improvements in the screen failed to stimulate sales. Future Computing Inc. of Dallas estimates 12,000 Data General/Ones will be sold in 1985, of a total 53,000 disk-based portables sold in the U. S.

The idea for this product grew out of the success other companies were having with desktop personal computers, an opportunity Data General missed. "We generally feel that when we miss a window, rather than playing catch-up, you're better off trying to intercept it at the next stage," says de Castro. "Our feeling was that the next stage is portables."

*CEO is changing to meet challenge of new office systems*

At the opposite end of the spectrum, the new superminicomputers unveiled in November represent the next step in the company's existing technical philosophy. Central to this thinking has been to continually reduce the number of boards used. "What we always thought minicomputers were was building one-board systems and see how far you could go, rather than building multiboard machines like the VAX 8600, which is really mainframe technology," says Tom West, vice president of systems development.

West notes that the new MV 20000 includes just four boards, compared with several times that many in a comparable VAX machine. The leanness of Data General's architecture translates into lower production cost, increased reliability, and ease of maintenance, he claims. By keeping the same bus structure since the Nova product line, says West, the company is spared having to increase levels of emulation or interpretation.

The technical advantage Data General might have at this point is confined to the high-end superminicomputers. Low-cost production is important, of course, but becomes paramount only as volume increases. And although price/performance is a great door opener, it doesn't ensure a sale.

This is the challenge facing Data General in the scientific marketplace, where the sale must often be made against DEC. "When you go against DEC in the scientific marketplace, people want the performance and they're willing to pay for that," says Steve Wallach, a Data General alumnus and central figure on the Eagle project who is now vice president for technology at Convex Computer Corp. in Richardson, Texas. "And Data General machines don't make the simulations run faster."

Also, DEC is sometimes able to narrow the price/performance gap by selling many of its high-end machines in clusters, which means central processing units may be added without the cost of additional input/output.

**AN UNIMPRESSED DEC.** As expected, DEC acknowledges the new Data General superminis and other product announcements with a yawn. "It was expected, nothing startling," says Robert Glorioso, DEC's vice president of high-performance systems. He maintains that one-to-one machine comparisons are beside the point, particularly because 80% of the VAX 8600s are being sold in clusters. "Our major competitor is IBM," he says.

However, in an August 1985 user survey conducted by Datapro Research Corp., Delran, N. J., customers gave Data General slightly higher grades than DEC in 14 of 25 areas. Against IBM, Data General garnered better grades in just 9 of the 25 areas surveyed, though slightly more of its customers said they would recommend the system to another user. Data General may also be able to exploit complaints among some users that IBM's System 36 quickly runs out of computing power in some office settings.

What Data General may now have to learn is the patience required to sell to Fortune 500 companies, something that may be difficult for its sales force. But as the consolidation in the business continues, Miller says, "The good news, I suspect, for people like us, is that it's going to be a less crowded track out there to race on." ☐

# THE DRIVE TO SHARPEN NTSC TV PICTURE BEGINS

## UNLIKE HIGH-DEFINITION TV, ENHANCED NTSC USES TODAY'S EQUIPMENT

**by David M. Weber**

**NEW YORK**

With high-definition TV seemingly stalled because its incompatibility with current TV standards would make all existing hardware obsolete, several new concepts are moving into hardware that will be able to improve the picture clarity of existing NTSC broadcast signals.

In Japan, set makers are already turning out TV receivers that will be able to enhance the resolution of an NTSC picture by employing frame memories and noninterlace interpolation displays. But this won't happen until broadcasters modify their existing transmitters and add new cameras. Sony Corp.'s Multi-Scan color monitors use a digital scan converter that converts a 525-line interlaced signal to a noninterlaced display of 1,050 lines. Also selling frame-memory sets in Japan now are Hitachi, Mitsubishi, and Toshiba.

In North America, two companies—M/A-COM Linkabit Inc. in San Diego and Scientific Atlanta Inc.'s Video Systems Division in Toronto, Canada—have developed enhanced-definition broadcast techniques that are also compatible with the receivers currently in use.

In purely technical terms, the 60-Hz, 1,125-line, 2:1-interlace High-Definition TV standard developed by the Japanese state broadcasting network, NHK, has an appealing ring. Indeed, almost all the major manufacturers in the Japanese TV industry have developed prototype HDTV equipment, but they won't start production unless NHK makes a firm commitment to begin HDTV broadcasting on satellites—the bandwidth requirements are too high for standard terrestrial channels [*ElectronicsWeek*, April 22, 1985, p. 19].

And no one will even guess when such transmissions would begin in the U. S. Therefore, the more appealing alternative to TV broadcasters now are these techniques that enhance the broadcast and reception of the pictures they are already transmitting.

This is where the advocates of enhanced versions of NTSC come in. They emphasize that their techniques will permit owners of conventional receivers to demodulate an enhanced signal with a simple set-top decoder.

**COMPETITIVE MODES.** Two different formats for enhancing the current 525-line NTSC standard used in most of the Americas and in Japan have been developed. Called BNTSC and MAC, they are now battling for acceptance in the technical community along with HDTV.

BNTSC uses a color subcarrier in addition to monochrome image information in a composite format very similar to that of NTSC, except that the horizontal blanking interval is replaced with digital audio signals, thereby avoiding the need for audio subcarriers. It transmits an

**FILM QUALITY.** NTSC's 525-line count is doubled by interpolation to give a demonstrably better picture resolution.

NTSC-compatible 525-line image that can be progressively scanned to display 1,050 lines on an extended-definition BNTSC receiver. A luminance bandwidth of 6 MHz (as opposed to about 4.2 MHz in conventional NTSC) carries enough information for a perceptibly sharper picture. Another main selling point is that BNTSC can be received with existing, unmodified receivers.

**EASILY BROADCAST.** Ron Katznelson, director of new technology in the Video Group at M/A-COM Linkabit Inc., which has designed and built equipment (under the name VideoCipher) for BNTSC broadcasts, emphasizes that BNTSC can be transmitted on any C-band and terrestrial broadcast using audio subcarriers above 6 MHz. To date, 19 U. S. satellite programmers plan to use 525-line BNTSC, and Home Box Office and CBS Inc. are using it now.

No satellite receiver modifications are required, so the more than 1 million U. S. owners of C-band satellite dishes can pick up BNTSC through a decoder, although a TV receiver capable of 1,050 lines is needed to take full advantage of a BNTSC extended-definition transmission (as opposed to high-definition, a term used to refer specifically to 1,125-line HDTV).

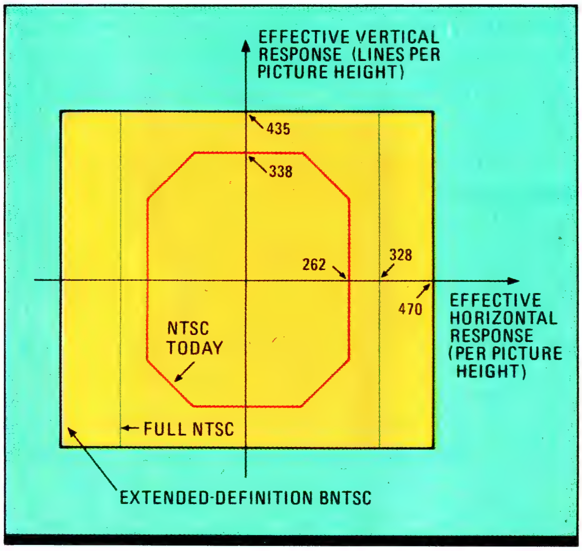
To display BNTSC in the 5:3 aspect ratio used by HDTV, an augmentation channel, which combines the bandwidths of two adjacent NTSC channels, is necessary to carry the additional sections of the horizontal lines. CBS Labs is promoting this approach—especially for wide-bandwidth C-band and $K_u$-band satellite transmission [*Electronics,* Oct. 6, 1983, p. 52].

The other NTSC-compatible standard is called MAC (for multiplexed analog component TV) or B-MAC in its newest version. It compresses luminance and baseband chrominance signals to a standard video active line. Because it doesn't have a color subcarrier, it can provide a direct red-green-blue output for enhanced displays. With a decoder, a standard composite-video receiver can demodulate the same B-MAC output.

All three signals in the B-MAC multiplex—luminance, chrominance, and data—are at baseband and insensitive to most of the high-frequency noise produced by FM channels. This particularly suits B-MAC to FM transmission by satellite.

The transmitted 16:9 B-MAC aspect ratio can be adjusted to fit into the 4:3 portion of standard 525-line NTSC without losing any audio or data services. The B-MAC signal, which supporters see being used primarily in pay-per-view programming by means of direct-broadcast satellites, is descrambled by removing the time compression of both the scrambling signals and the compressed video line. For dual-aspect-ratio reception, the 4:3 part of the 16:9 picture can be selectively decompressed to a set-top decoder to occupy only the dimensions of a standard receiver.

Because there is no color subcarrier, NTSC artifacts such as cross color and cross luminance do not appear in B-MAC. Cross luminance is eliminated by time-compressing the luminance signal to 35 $\mu$s of the 52.5-$\mu$s active luminance line. The remaining 17.5 $\mu$s is thereby made available on the same line for the color-difference signal—effectively removing any interference between luminance and chrominance.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338
262
328
470
EFFECTIVE HORIZONTAL RESPONSE (PER PICTURE HEIGHT)
NTSC TODAY
FULL NTSC
EXTENDED-DEFINITION BNTSC

**EXPANSION.** Standard NTSC is expanded to give a wider aspect ratio for better definition.

Keith Lucas, engineering manager of Scientific Atlanta's Video Systems Division, explains that though B-MAC is optimized for DBS transmission, its noise figures for cable are actually better than standard NTSC, despite the absence of a color subcarrier. Support for the B-MAC camp comes from the European Broadcast Union, which has recently adopted a 625-line version of B-MAC, called D2-MAC, for cable transmission. Elsewhere, an Australian DBS satellite is now using B-MAC, and decoders for existing receivers are being produced in Australia for homes in remote communities.

**A DEVELOPING PICTURE.** Whether HDTV will be scrubbed in the face of competition from enhanced versions of NTSC depends more on commitments from broadcasters than on its technical characteristics (which are, in fact, superior to those of the improved versions of NTSC). As is the case with any new standard, official approval would enhance its chances for success in the market, and universal approval for HDTV remains tentative in the face of uncertain consumer demand.

The International Consultative Committee on Radio (CCIR) has seemed on the verge of endorsing NHK's HDTV standard in response to its endorsement by the U. S. and Japan. European broadcasters, however, citing incompatibility with the Continent's 50-Hz line current, have withheld their approval for HDTV broadcasts.

**RISKY INVESTMENT.** However, the European Broadcast Union has given the nod to HDTV as a studio standard to replace film in making movies. Although CCIR approval is not essential, no one has been willing to undertake the risk of investing in HDTV broadcast equipment that is incompatible with anything now in use.

For advocates of both B-MAC and BNTSC, the compatibility of their extended-definition broadcasts with standard 4:3-aspect-ratio NTSC receivers will be a major selling point to consumers who don't want to throw away the TV sets they already own. If EDTV receivers are produced in quantity, both parties argue, consumers could buy them as replacement sets.

"It's a chicken-and-egg situation," says M/A-COM Linkabit's Katznelson. "NHK may want to gamble on its ability to create a de facto standard with 1,125-line HDTV, but the TV manufacturers are out on a limb if they start up a production line [for HDTV receivers] on account of a few NHK broadcasts."

"Availability of enhanced-definition large-screen displays will probably be decisive in determining how the market goes," in Lucas' view. "But with B-MAC transmission on an RGB display, you've already taken the first step to improved definition," he says.

Accordingly, Scientific Atlanta is looking first to B-MAC satellite transmission for areas that cannot adequately receive terrestrial broadcasts—there are an estimated 5 million such homes in North America alone. If a broader market develops for improved picture resolution—especially if RGB receivers become popular—the extended-definition version of B-MAC can be implemented with the same DBS satellites.

Proponents of BNTSC also see an advantage in a gradual approach. Their first offer to the consumer is an improved NTSC picture on today's high-end receivers. If the consumer wants still better picture fidelity, BNTSC can be modified to provide it with existing transmitters. ☐

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Industry Split on Size of 1-Mb DRAM Package

### June

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Components Outlook

# SHOULDN'T YOU BE BACK?

# WESTERN DIGITAL'S PLAN TO ELIMINATE 'WEAK SPOT'

## MAKER OF PROPRIETARY SUBSYSTEMS GOES AFTER END USERS TO END DEPENDENCE ON PC MAKERS—AND IBM IN PARTICULAR

**AWARE.** Western Digital's Johnson wants to leverage controller business.

**IRVINE, CALIF.**

Companies that live by the dealings they have with IBM Corp. often die if Big Blue takes its business away. So Western Digital Corp., which has carved out a healthy niche supplying peripheral controller boards to IBM for its Personal Computers, has put in motion a plan to sell a new line of PC products to those who already own computers.

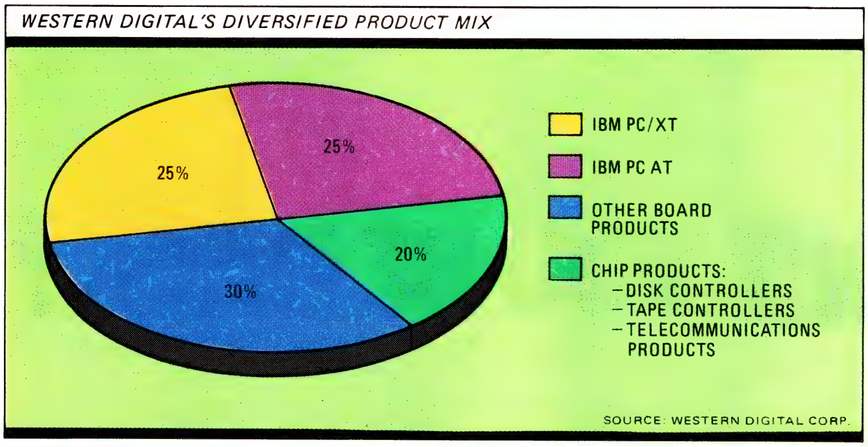
Western Digital wants to leverage its position as the leading supplier of controller boards to IBM PCs and PC-compatible machines by selling a new line of plug-in memory boards for the thousands of IBM and IBM-compatible personal computers already on customers' desks. By going after new markets, it hopes to kick off a new round of profitability and growth.

The company has gone through three distinct phases during its rocky 15-year corporate life. Along the way, it has attracted keen industry attention, beginning as a pioneer of silicon-gate integrated circuits and the first commercial 16-bit microprocessor chip set. Then in the mid-1970s, it came up with industry-standard telecommunication data chips and floppy-disk controllers. It later flirted for about four years with developing a line of personal computers and engineering work stations before dropping them in 1982 because of the competitive nature of the business.

Chairman and president Roger W. Johnson readily concedes that his company does not lend itself to neat definition in any of the standard industry categories. In fact, he takes pains to avoid having a semiconductor label hung on the company. "We design and produce proprietary chips and subsystems that fill a niche." "Controlling things" is his generic description of this niche.

**HEAVY R&D.** To this end, Western Digital spares little in research and development to maintain leadership in disk-control hardware. In 1985, the company spent nearly $12.5 million on R&D. Western Digital continually upgrades its controller products, and it now has 30 chips serving the market. This year, it added the single-chip WD33C92 bus controller for the Small Computer System Interface, which appears to be the emerging standard for linking peripherals in small computers.

*WESTERN DIGITAL'S DIVERSIFIED PRODUCT MIX*



SOURCE: WESTERN DIGITAL CORP.

Western Digital's biggest success this year in the original-equipment-manufacturer market, says Johnson, is a hard-disk-drive controller board—the Cobra—for IBM PC/XTs and compatible computers. The Cobra, which contains six of the company's proprietary very large-scale integrated circuits among a total of 17 chips, illustrates what Western Digital does best, he says.

What's more, the board, which uses only conventional through-hole mounting techniques, is 40% smaller than competitors' boards. And a new surface-mounting technology program Western Digital has started, deemed by outside sources as one of the industry's best, will reap further benefits for the boards by shrinking them even more, Johnson says.

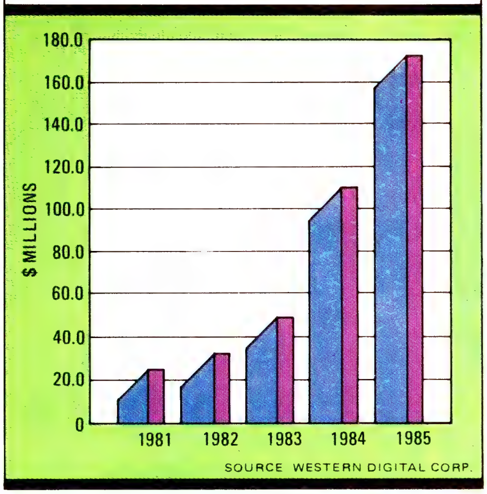
Little doubt exists that Western Digital can stay ahead in the semiconductor controller market, believes Joseph Jaworski of Peripheral Concepts Inc., an Irvine, Calif., consultant who closely tracks the field. "They've held the lion's share since 1981," he says, putting the Western Digital share at slightly more than 36% for 1984 and 1985. At the board level, Western Digital vies with Xebec, San Jose, Calif., for the No. 1 spot, but it holds a clear edge with its board for the best-selling IBM PC AT.

If Western Digital has a weak spot, it is its dependence on the personal computer business in general—and IBM in particular—say analysts who follow the company. Sales to IBM accounted for 41% of Western Digital's 1985 total sales of $177.4 million.

However, such a close relationship may not be as bad as it looks, says John M. Geraghty, who follows Western Digital for New York's First Boston Corp. For one thing, the 1985 total was swollen by one-time deliveries of PC AT boards. For another, the company is not tied so tightly to any single IBM product that a cancellation would be ruinous. In addition, Geraghty thinks that orders from makers of IBM PC clones will go up. And even if IBM should start making its own controller boards, it would still need Western Digital's chips.

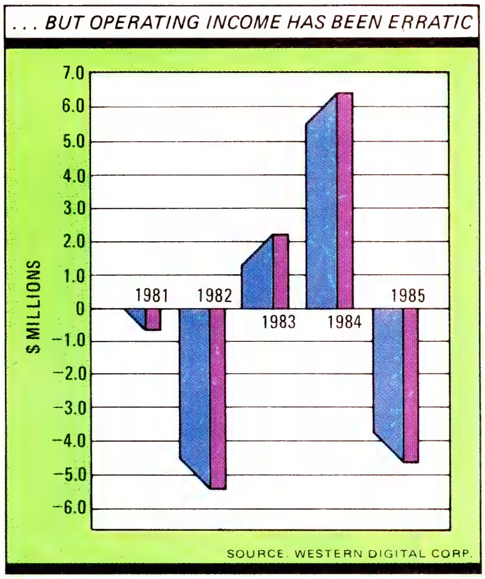
Nonetheless, Johnson is covering his bases. The first four products in his aftermarket initiative were introduced at the Comdex show in November. These consist of FileCard, a 10-megabyte drive on a plug-in controller card; a memory-enhancer board for FileCard, which offers from 128- to 512-K of extra internal memory; PortaFile, a 10- or 20-megabyte Winchester portable expansion system; and WD60Ti, a 60-megabyte, ¼-in., in-

WESTERN DIGITAL'S REVENUE HAS GROWN . . .



SOURCE: WESTERN DIGITAL CORP.

. . . BUT OPERATING INCOME HAS BEEN ERRATIC



SOURCE: WESTERN DIGITAL CORP.

ternal tape-backup system that includes the Cobra controller board.

The benefits to Western Digital in selling these add-ons speak for themselves, Johnson notes, because "they are loaded with my chips." What's more, the company has put a year's effort into planning the new business, hired people experienced in selling microcomputer goods through nondirect sales channels, and spent heavily (up to $10 million, according to some sources) in preparation.

Johnson is sure his company has found a way to sell to the user, a strategy that has always eluded industrial suppliers. Its distribution mainstay, rather than computer stores, is a regional network of 11 value-added resellers.

**PIGGYBACK.** Although a number of peripherals companies have crowded into the computer aftermarket recently and done well at first, the longer-term prospects are cloudier. But the economies of scale make sense from Western Digital's position, believes John C. Ball, a research analyst for Paine Webber Inc., New York. "If they can piggyback strong OEM business, it would be no surprise to see it become a big success."

Johnson says the program is off to a flying start and will contribute some $20 million in revenue to the current quarter. What's more, the potential for aftermarket products is even larger than the market for OEM products sold to personal computer makers, which will amount this year to about $9 billion, including software, according to Johnson's figures. He sees this more than tripling by 1990.

Western Digital's financial performance over the years has often been good, based on its position in then leading-edge products, such as data-storage chips and subsystems, which remain its core strength. But overambitious goals against the backdrop of industry downturns had disastrous consequences, including a stint in Chapter 11 bankruptcy proceedings during the mid- to late-1970s.

Western Digital claims it has closed the books on its latest troubles, the fiscal 1985 fourth quarter, ended June 30. In that period, Western Digital grew so fast that a change in the mix of business, manufacturing inefficiencies, and a ballooning inventory of outdated parts combined to cause a $13.4 million loss for the quarter, and a $4.6 million deficit for the year.

The company bounced back into profitability in the first quarter of fiscal 1986, with net earnings of $3 million on sales of $62.9 million. In the same period of fiscal 1985, it earned $2.79 million on sales of $38.3 million. Western Digital corrected the worst production problems mostly by cutting costs of board-level products, which earlier had skyrocketed from the reworking of some circuit boards that proved faulty. It also cut back on expensive overtime in manufacturing operations. Personnel costs also were pruned through selected layoffs.

Johnson foresees a "pretty strong" year for the company, but his strategic attention is focused on other goals. He says the company has the ingredients—quick turnaround, design automation, and new fabrication facilities—that enable it to compete in application-specific-semiconductor markets.

The die is already cast for moving into related product areas, such as imaging products, that will give the company a different look. That's why Johnson predicts that within two years, Western Digital will be quite different from what it is today, more akin to an application-specific-IC company than to a peripherals maker. *—Larry Waller*

## BOTTOM LINES

### 3M CONSOLIDATES MAGNETIC MEDIA UNITS

3M Co. has merged its audio, video, and data-recording products into a new division within its Memory Technologies Group. The Magnetic Media Division will make and market all magnetic media in open-reel, cartridge, cassette, and disk formats. The St. Paul, Minn., company says the group, which it calls a logical evolution in its strategic planning process, will "reinforce our market leadership and will continue to be the world's most efficient supplier of advanced-technology magnetic media." Research and product-development work for the full line will be handled by a new group-research organization.

### XILINX RAISES $8.3 MILLION MORE

Semiconductor startup Xilinx Inc. has received $8.3 million in its second round of venture financing. The San Jose, Calif., company makes and markets user-programmable integrated circuits and development systems based on its logic-cell-array technology. Xilinx, which was founded in March 1984, says the funding will be used for new product development as well as for market development and working capital.

### BRITAIN'S REED BUYS ONLINE COMPUTER

As part of its strategy to become a premier electronic publishing company, London's Reed International plc has acquired Online Computer Systems Inc., a computer research and services company in Germantown, Md., for an undisclosed amount. Online officials say the acquisition will provide them with the "deep pockets" needed to finance international marketing as well as to develop new ways of delivering information electronically. Reed, a holding company with sales of $2.5 billion, includes among its holdings Cahners Publishing Co., Boston. Online, a privately held company founded in 1979, had revenue last year of about $6 million.

### IXYS GETS SECOND ROUND OF FINANCING

Ixys Corp., a designer and maker of CMOS integrated circuits, power semiconductors, and smart power ICs for motion-control applications, has raised $6.7 million through a second round of venture financing. The San Jose, Calif., company, which was founded in 1983, hopes to start introducing some of its products next month.

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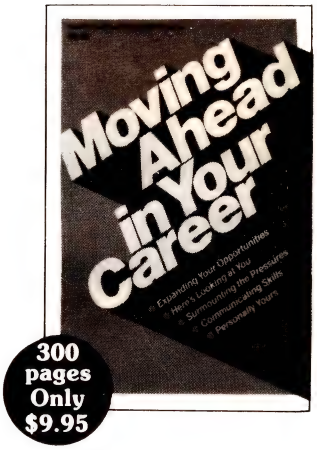
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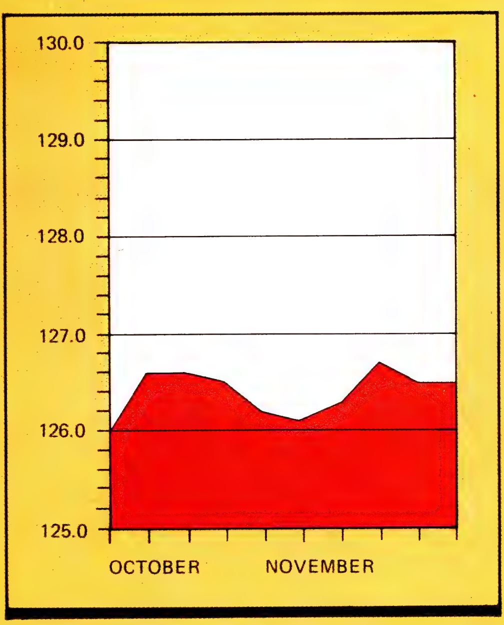
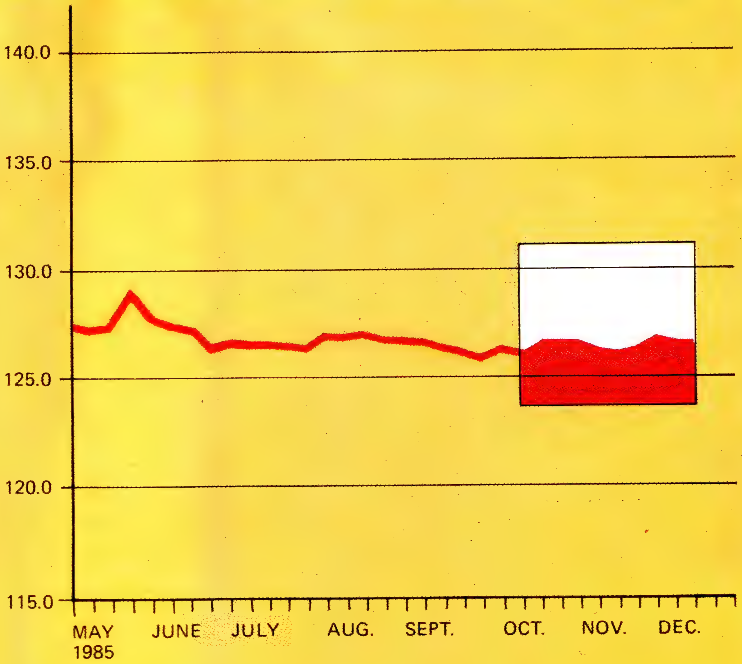


THIS WEEK = 126.5
LAST WEEK = 126.5
YEAR AGO = 129.8
1982 = 100.0



The *Electronics* Index, a seasonally adjusted measure of the U.S. electronics industry's health, is a weighted average of various indicators. Different indicators will appear from week to week.

## U. S. ELECTRONICS INDUSTRY EMPLOYMENT

| | October 1985 | September 1985 | October 1984 |
|---|---|---|---|
| **Production workers** (thousands)<br>Office and computing machines | 171.8 | 173.6 | 208.5 |
| Communications equipment | 291.5 | 288.5 | 290.1 |
| Radio and TV receiving equipment | 58.2 | 59.0 | 64.5 |
| Components | 353.3 | 355.7 | 415.8 |

## U. S. GENERAL ECONOMIC INDICATORS

| | October 1985 | September 1985 | October 1984 |
|---|---|---|---|
| Average prime rate (%) | 9.50 | 9.50 | 12.58 |
| Retail sales ($ billions) | 115.512 | 119.409 | 108.974 |
| Unemployment rate (%) | 7.0 | 7.0 | 7.2 |

Although the *Electronics* Index remained flat for yet another week and is down 2.5% from its level of a year ago, the slowing decline in the U. S. electronics industry's employment indicates that the industry could be about to make a turnaround. According to the latest government statistics, U. S. manufacturers continued to trim their payrolls in October, but the ranks of workers slipped a mere 0.2%.

Total employment in the U. S. electronics industry has dropped an average of 1% each month over the past year. October's comparatively benign drop could mean that layoffs in the overall industry may be reaching bottom.

Still, an examination of the details of the October labor situation shows that only manufacturers of communications equipment added to their payrolls. Employment in this sector climbed 1% in October. That increase brought employment in this industry sector up slightly from year-ago levels. Manufacturers of radio and TV equipment slashed their worker ranks by 1.4% in October, bringing the labor force in this segment to a level just 91% of what it was last year at this time.

Manufacturers of computing and office equipment cut their work forces by 1% in October. With a 17.6% decline compared with this time a year ago, employment in this sector has contracted more than any other in the U. S. electronics industry.

In the U. S. components industry, manufacturers trimmed payrolls by 0.7% in October. This means that for every 100 people employed in October 1984, just 85 are working now.

## PEOPLE

# HOW GHOSH WILL MOVE GRUMMAN INTO GaAs

**PRINCETON, N. J.**

Gallium arsenide is commanding attention these days as the answer to military requirements for fast, radiation-hardened integrated circuits, and big defense contractors are rushing to get their development efforts rolling. Not to be left out, Grumman Corp. expects to open its GaAs operation, Tachonics Inc., in Princeton sometime next month under the presidency of Chuni Ghosh.

**OLD HAND.** Ghosh has worked with GaAs for over 10 years.

The 37-year-old Ghosh has been working with GaAs since the mid-1970s, and spent the last five years with ITT Corp. as manager of GaAs fabrication. But at Tachonics, he will face different challenges. As president of the wholly owned Grumman subsidiary, he will for the first time have to face ledger sheets and corporate boards with an eye skewed more toward business than research and development.

Born in India, Ghosh won his doctorate from the University of Bombay in 1976. He came to the U. S. in 1979 to do postdoctoral research at the University of Oregon, signing on with ITT soon thereafter. "I wanted to come to the U. S. for a year, maybe two, and then go back to India," he recalls. "I was in a good position in India—I got the Engineer of the Year award from the National Academy of Science."

But the challenge of working for a large multinational corporation such as ITT made him postpone the trip home for one year, then another. "At ITT, we set up a GaAs IC lab," he says. "I was in charge of technology and technical development, and ITT became one of the leading manufacturers of GaAs ICs with Raytheon, Triquint, and Texas Instruments."

But at Tachonics his job will be much bigger, and Ghosh will have to remove himself to some degree from the technology to concentrate on other parts of the business. "I'm very enthusiastic," says Ghosh.

Going back to India now would not be feasible, he says. His two children, now 11 and 7 years old, have been brought up in this country and began their education here, adding family complications to any personal desire to leave.

Not that things are so bad here. Wary of explaining his exact relationship with Grumman, Ghosh declines to comment on whether he has an equity stake in the new company and on precisely when and how he came to be involved with the Bethpage, N. Y., defense contractor. He does say, however, that he had considered other financing alternatives and decided that "if money is available—from whatever source—it is good."

**POTENTIAL PARTNER.** Ghosh says he knew Grumman, a newcomer to the semiconductor business, was interested in GaAs technology before his departure from ITT in July and indicates that he sought out the company as a potential business partner. Although he remains tight-lipped about the amount Grumman is investing, it is generally considered that between $25 million and $50 million are needed to set up a workable GaAs production facility.

Tachonics, which Ghosh says will be "medium-sized," will concentrate efforts on analog ICs, where most of the military work will be aimed. He says the Japanese, who many believe are ahead of the U. S. in GaAs research, lead in the digital area, but not in analog ICs. The first big account Ghosh will try to land is funding from the Microwave Monolithic Integrated Circuit Program now planned by the Department of Defense.

"Certainly, technology is something I enjoy very much, and I don't want to waste my background. For a year or two I will be involved with it still, but I will have to let go. That was a difficult decision." *–Tobias Naegele*

## PEOPLE ON THE MOVE

**THOMAS A. DODGE**

□ Honeywell Inc. has appointed Thomas A. Dodge director of project operations for the Manufacturing Systems Division, with headquarters in Phoenix, Ariz. Most recently, Dodge was manager of Northeast project operations for the Process Management Systems Division in Fort Washington, Pa. He has held a variety of supervisory and management positions in Honeywell's aerospace and defense division over the past 22 years.

**JAMES F. McDONALD**

□ James F. McDonald, the 45-year-old president and chief operating officer of Gould Inc., will become president and chief executive officer of the Rolling Meadows, Ill., electronics conglomerate effective at Gould's annual meeting April 29. The move is in line with a management-transition plan announced in July 1984, when McDonald moved into his present job following a varied career that spanned 21 years at IBM Corp. [*ElectronicsWeek*, Oct. 1, 1984, p. 41]. William T. Ylvisaker, 61, Gould's chairman and CEO, will retain the chairmanship and assume the additional title of chairman of the executive committee of the board, focusing on strategic planning.

**HAROLD MATTICE**

□ The new vice president of manufacturing operations for ITT Qume Corp. is Harold Mattice. He had been a consultant for Qume, a San Jose, Calif., maker of computer peripherals, and joins the company from Operations Management Consultants, where he was president. In his new position, Mattice will be responsible for Qume's manufacturing operations in Puerto Rico and Taiwan.

**RAFAEL CHATAV**

□ Daisy Systems Corp. has appointed Rafael Chatav as group vice president of its physical design automation group. The group is responsible for providing physical design implementation for custom very large-scale integrated circuits, printed-circuit boards, and electromechanical packaging and styling. Chatav is cofounder of Daisy Systems and has served as an officer of the Mountain View, Calif.-based company since April 1982. His most recent position was vice president and general manager of Daisy's analog division. Before Daisy, Chatav was a project manager for Dataproducts Corp., a manufacturer of computer-peripheral equipment. He holds a BS in electrical engineering from Technion Institute in Haifa, Israel.

**ALBERT A. EISENSTAT**

□ The vacancy on Apple Computer Inc.'s board left by former chairman Steven Jobs's resignation in September has been filled by its general counselor, Albert A. Eisenstat. Concurrent with his board appointment, he was promoted to senior vice president. Eisenstat, who has been with the Cupertino, Calif., company since 1980, will continue to oversee all its legal matters, as well as take on more responsibility for business development.

**PEOPLE**

# A NEW BREED OF MANAGER TO RUN TRW COMPONENTS

**EL SEGUNDO, CALIF.**

The new hand at the helm of TRW Inc.'s Electronic Components Group come Jan. 1 likely will steer the highly diversified organization along some new routes. Lester Hill—no one ever calls him anything but Buck—takes over at a time when all such parts businesses have suffered the blues of a recession, which itself is often a catalyst for change. But his own record is that of a man unafraid to move on to new things.

**TAKING CHARGE.** Hill brings both technical and financial experience to the job.

Hill next week formally assumes the title of vice president and general manager of the nearly $450 million group when Karl E. Heller, who has held the post since 1979, retires. TRW quietly announced the succession in August, but only to its executives, in order to provide a transition period for Hill to serve as a deputy to Heller.

Hill, 41, says this orderly transition is typical of TRW and the only way to change the guard. "It allows the luxury of phasing in. The alternative would be coming in cold and having to make 15 decisions in an hour." The energetic Hill previously spent two years running the group's Electromagnetics Unit, which manufactures passive components, motors, and assembly operations. While he immersed himself in operating details of the overall group, Hill also has engaged in "thinking time that could lead to launching whole new directions."

One way to accomplish this, Hill concludes, is to exploit more fully an advantage his group enjoys over its competitors: accessing the treasure trove of technology generated at TRW's Electronics and Defense Sector in nearby Redondo Beach. That systems operation is a recognized leader in semiconductor device and communications work for the Pentagon, including selling signal-processing chips in the Very High-Speed Integrated Circuits program.

Transferring military technology to commercial products, however, even inside a corporation that encourages it, remains one of the most daunting managerial tasks around, Hill admits. But he points out that his group's most visible division, LSI Products, came from just such a move in the late 1970s, and he had a part in it as a jack-of-all-trades aide with the title of director of financial control.

Most industry sources single out LSI Products, with its trailblazing signal-processing parts, as the prototype for injecting military know-how into the commercial world. "We would like to do more of this," says Hill.

**GETTING AROUND.** Hill has had varied experience at TRW, which recruited him as a newly minted MBA from Harvard University's Business School in 1968. He had received his BSEE magna cum laude and Phi Beta Kappa from Duke University. His first assignments were designing rocket systems for spacecraft positioning, nuclear-power equipment for spacecraft, and ion-propulsion systems. In 1979, after helping acquire companies that became the group's Optoelectronics Division in Carrollton, Texas, he became the divi-

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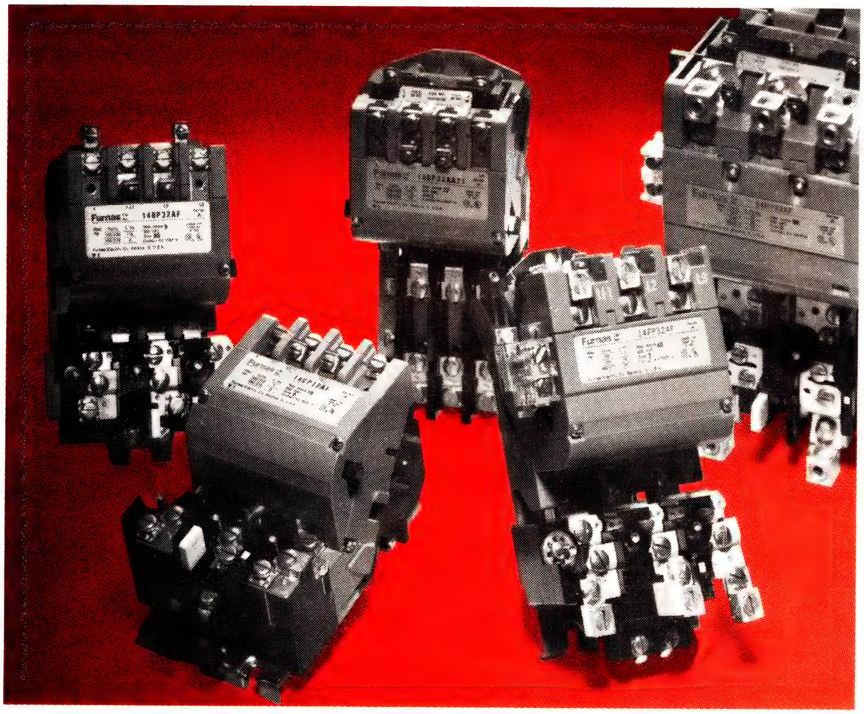

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sion's manager. By 1984, Hill had tripled the size of the division.

Hill's management style is "shirt-sleeved and informal, but intense," say associates. Thus, he is more likely to seek out his staff executives in their offices to get information quickly. This penchant for on-the-spot meetings has let Hill get up to speed with his operations by visiting the group's divisions "more times since August than Karl Heller did in five years," observes one staff member.

Heller says that his successor clearly represents a new breed of top management with financial and technical experience, in contrast to himself and Hart, who were veteran components-marketing executives. Hill's background is needed to guide the TRW organization during what Heller calls "a time for transition. It really is."

## *Hill aims to inject military know-how into commercial world*

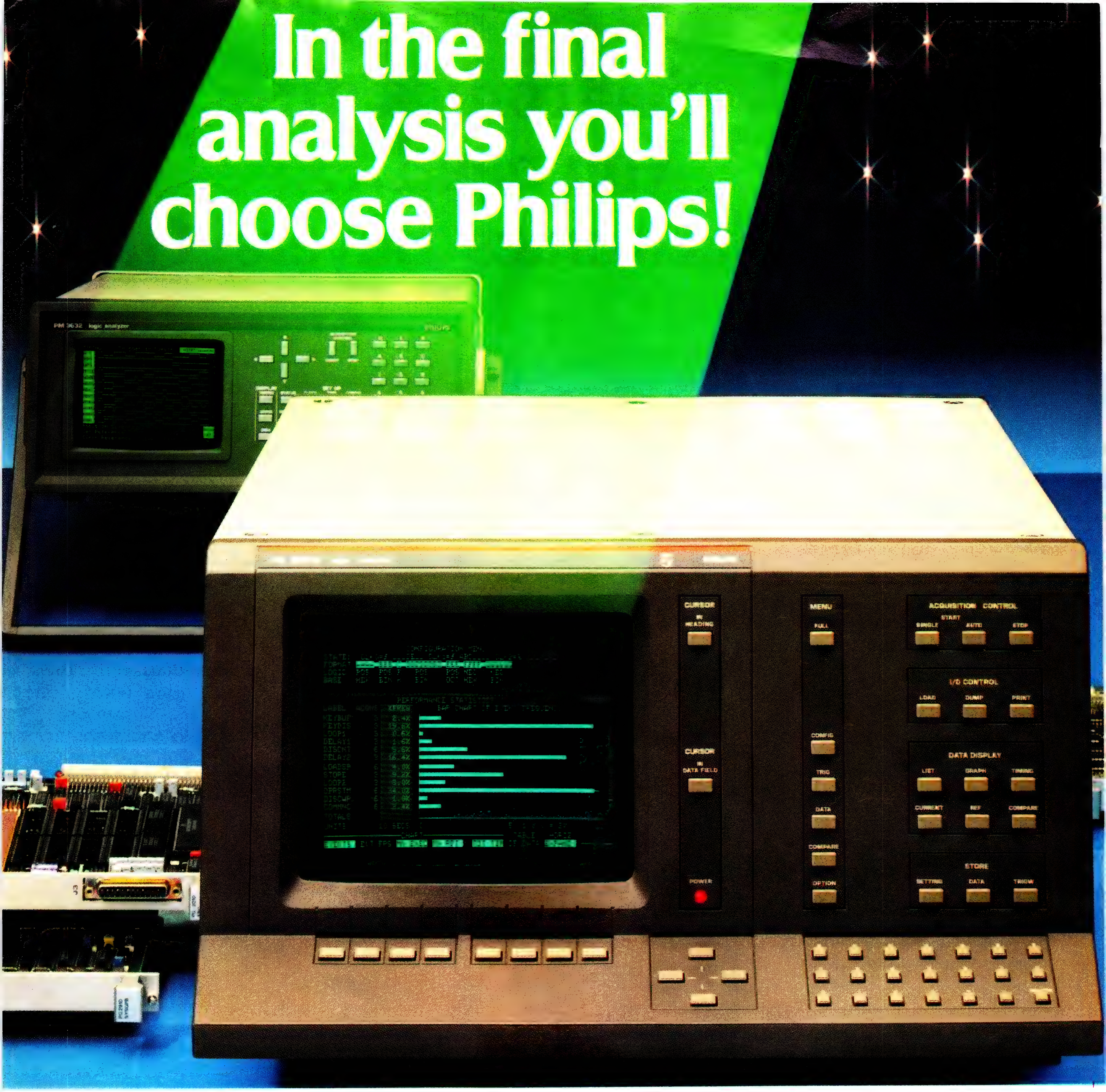
His reasoning is that technology businesses always have been volatile, but intensified worldwide competitive pressures have turned the heat up even more. Also, Heller points out, changes have always been a hallmark in the group. "I've sold off 11 businesses myself since 1979."

While Hill is getting control of the management machinery to guide the group into a year that still appears "flat, maybe even down a couple of percentage points," he is also peering more deeply into the current troubles of the industry. What puzzles him is why such leading-edge businesses, which always have paced economic development, should now be in the doldrums when overall gross national product is on the way up. "I don't know the answer, and it's disconcerting," he says.

**SHIFTING GEARS.** Finding answers is more than just an intellectual exercise for Hill. "We have to understand the dynamic forces that have disconnected us from the general economy—the drivers, I call them," he says. The payoff he sees for companies that "first sense the fundamentals of change is to find an advantage" that can be invaluable in product planning and positioning.

In the meantime, Hill particularly relishes the challenge of dealing with a multitude of businesses, from semiconductors to overseas assembly operations. "That makes it fun, having a finger in so many pies."

He leaves little doubt, however, that within five years, the flavor of the TRW pies will be very different from those of today. *—Larry Waller*



# Philips' PM 3551 A and PM 3632 Logic Analyzers

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Circle 83 on reader service card

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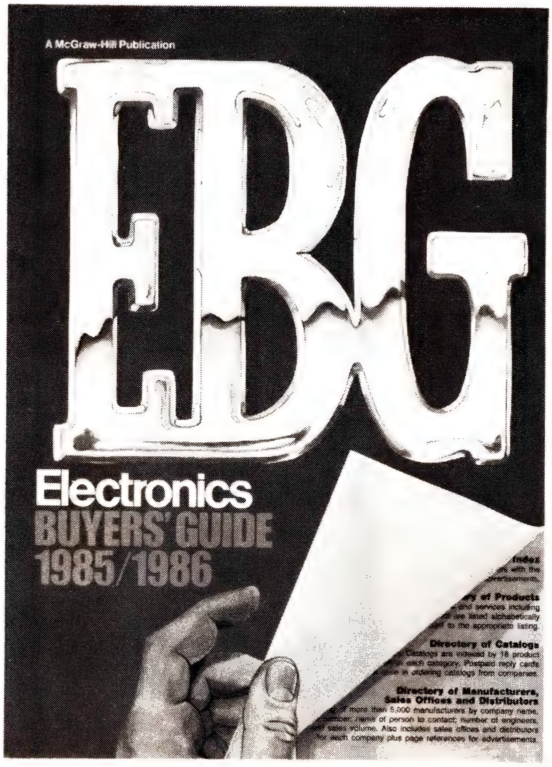
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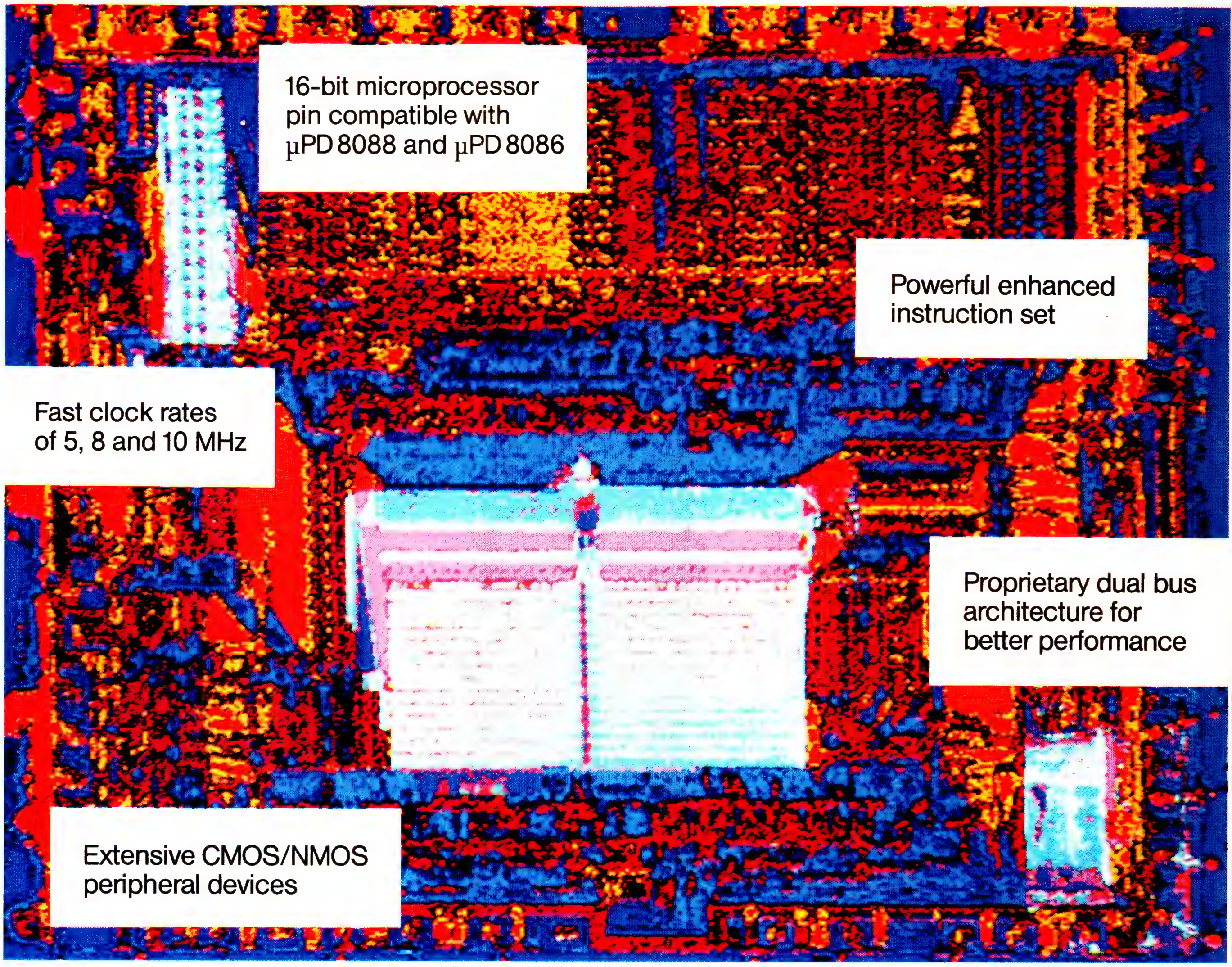
Circle 84 on reader service card

# The V20/V30 superior performance at lower cost



16-bit microprocessor pin compatible with µPD 8088 and µPD 8086

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V series

NEC's proprietary CMOS technology and innovative dual bus architecture provide up to 40 per cent increase in speed and 70 per cent reduction in power consumption over standard NMOS processors. This technology allows for extremely high densities, up to 700,000 transistors, on a single chip.

As direct replacements for the µPD 8088 and µPD 8086, the V20 and V30 microprocessors use an enhanced set of 101 instructions and support 8- and 16-bit external data buses respectively. In addition, NEC offers flexible development support: its stand-alone in-circuit emulator features built-in intelligence, on-line debugging at symbolic level, both active and passive probes and it can be connected to various standard hosts. The V-series standard microprocessor family is also supported by HP and Tektronix development tools and is second sourced by Zilog and Sony.

West Germany: Düsseldorf (0211) 650302, Telex 858996-0;
The Netherlands: Eindhoven (040) 445845, Telex 51923;
France: Paris (1) 39469617, Télex 699499;
Italy: Milano (02) 6709108, Telex 315355;
Sweden: Täby (08) 7567245, Telex 13839;
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NEC

# NEW PRODUCTS

## CARDS GIVE IBM PCs HIGH-END GRAPHICS CAPABILITY

### IMAGRAPH'S CONTROLLERS DRAW AT 2.5 MILLION PIXELS PER SECOND

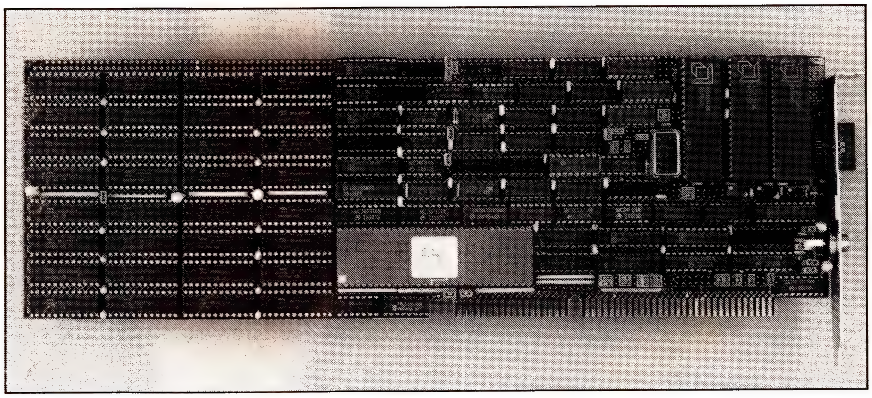
The high-resolution display required in work stations for applications such as computer-aided design and engineering, graphic arts, and scientific work is becoming more available on personal computers. Now a new family of graphics controllers brings the speed and resolution of high-end graphics systems to the IBM Corp. Personal Computer/XT and AT at as little as half the price of a stand-alone graphics work station.

Imagraph, a startup in Woburn, Mass., offers a $4,495 graphics card that can be combined with a $4,000 PC AT for a graphics system with better resolution than a $17,000 Apollo work station. The Advanced Graphics Controller (AGC) products are also the first to combine all three leading-edge technologies designed for graphics equipment: the Hitachi Ltd. HD63484 Advanced CRT Controller (ACRTC) chip, NEC Corp.'s 256-K video RAMs, and Advanced Micro Devices Inc.'s new 200-MHz 8151 video digital-to-analog converter. Thanks to this combination, the AGC achieves a drawing speed of 2.5 million pixels per second in a 60-Hz noninterlaced display.

The Imagraph controllers' drawing speed is faster than the boards in Number Nine Computer Corp.'s Revolution series, which clock in at 2 million pixels/s [*Electronics*, June 17, 1985, p. 61]. But in most other specifications, the two product lines are similar. Both use the Hitachi chip for the graphics engine and both have addressable display memory for 2,048 by 1,024 pixels, which is standard on the Revolution line and an option on the AGC boards.

**FAST FILLS.** The engine on the AGC controller board accepts drawing commands directly from the PC's CPU. The AGC processor handles such commands as line, circle, arc, ellipse, and polygon drawing. Advanced commands such as patterned area fill, window clipping, 1× to 16× zooming, panning, and scrolling are also executed swiftly. Display data is stored in the controller board's dual-ported video RAM. The PC's CPU and direct-memory-access circuitry permit the PC to access video memory directly.

The AGC boards are suitable for any application that requires high-speed color graphics with high resolution. The company expects the product line to be used in PC AT-based CAD and CAE work stations, graphic-arts systems for page composition and pagination, and medical imaging applications, especially where a full-screen X ray or other image is to be displayed with high resolution. Imagraph also sees uses in geophysical exploration, mapping, and industrial process-control graphics.



**FAST.** Imagraph's card supports addressable resolution of up to 2,048 by 1,024 pixels.

The three basic products are the $4,495 AGC-1280, with a displayable resolution of 1,280 by 1,024 pixels; the $3,995 AGC-1024 (1,024 by 1,024 pixels); and the $2,995 AGC-512 (512 by 512 pixels). The AGC-1280 and AGC-1024 have displayable memory 8 bits deep, and the AGC-512 sports a 32-bit depth. With the 8-bit-deep memory planes, a total of 256 colors can be displayed simultaneously from a programmable palette of 16.8 million. Up to three of any of the 8-bit models can be stacked for 24-bit memory-plane depth.

The AGC-1024 also comes in a $1,995 4-bit-deep version. Another lower-cost version of the 1,024-by-1,024-by-8-bit controller has an interlaced 60-Hz refresh rate and sells for $2,500.

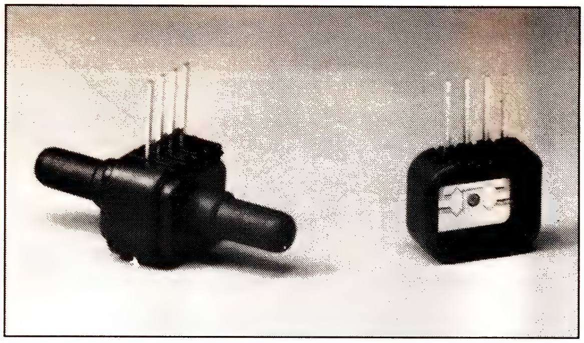
A version of the AGC products for connection to the VMEbus will be available in February. A Q-bus version for use with Digital Equipment Corp.'s MicroVAX II systems will be coming in March, says company founder and marketing manager Robert Wang. Delivery takes 30 days. *–Tom Manuel*

Imagraph Corp., 400 W. Cummings Park, Suite 3600, Woburn, Mass. 01801. Phone (617) 938-5480 [Circle reader service number 338]

## SILICON PRESSURE SENSOR IS PRICED AT ONLY $10

Low-cost sensor technology is here, and Honeywell Inc.'s Micro Switch division is hitting the $10 mark with the 16PCD line of pressure sensors. Yet the company is not sacrificing design subtleties in the process. Despite its low cost, the 16PCD is a true wet/wet sensor—it will tolerate most types of liquid media on both sides of the sensing chip.

The combination of elastomer O-ring seals, the use of tape-automated bonding, and thin-film laser-trimmed resistors contribute to the lower cost. Silicon-diaphragm pressure transducers have gotten appreciably cheaper in the past 10 years and "it's still a price-elastic market," says Jim Fitzsimmons, product manager for Micro Switch's pressure-sensor operations. Since 1978, when a sensor-only, nonamplified device from



**ALL WET.** A true wet/wet pressure sensor, the 16PCD uses tape-automated bonding to cut fabrication costs.

Micro Switch went for $30 in large quantities, the price has fallen to $15 and now to $10. The price eventually will drop below $10, Fitzsimmons says.

The seal design makes this pressure sensor truly rugged. The bonding pads on the IC were moved to the corners of the die to make room for the elastomer seals. Also, the ports that admit the pressure media to the diaphragm were ultrasonically welded in place. The result is a device that can function in industrial or process-control systems—where it puts the host computer directly in touch with the media being monitored—in barometric-pressure sensing, or in medical instrumentation.

**TAB SAVINGS.** Fitzsimmons also credits the integrated packaging design of the 16PCD for lowering the cost. TAB assembly creates bonds up to 10 times stronger than conventional wirebonding and is less expensive. Only eight interconnections are required, which increases reliability. The TAB connections are isolated from the ambient medium by the O-ring seals, and the suspended IC is supported by the TAB bonds. The result is a die isolated from the package and any stresses it may undergo in assembly or in operation. The entire sensor is enclosed in a miniature black thermoplastic package with terminals for easy mounting on circuit boards.

Models come in pressure ranges of 0 to 5, 0 to 15, and 0 to 30 lb/in.$^2$. They offer good linearity and sensitivity as well as repeatability, low hysteresis, and long-term stability. Thin-film resistors allow close control of sensor parameters. The on-chip resistors are connected in a four-active-element bridge for best linearity and sensitivity.

Sensors are interchangeable, and customers can specify the seal material according to the demands of the medium in which the sensor will be used. The only limitation on this technology is imposed by highly corrosive media that would affect the housing material, the silicon chip, or the elastomer seal.

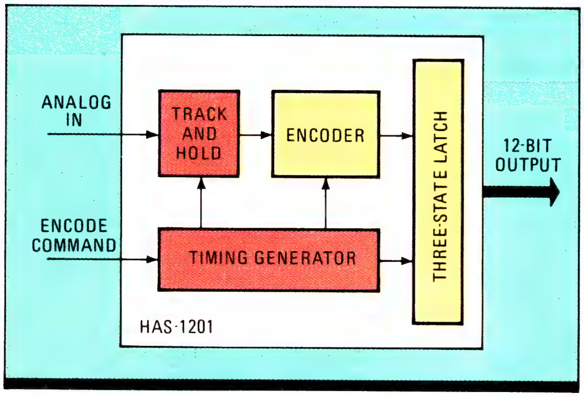
The 16PCD series costs $10 each in quantities of 5,000, and delivery takes four to eight weeks. *–Ann Jacobs*

Micro Switch, 11 W. Spring St., Freeport, Ill. 61032.
Phone (815) 235-6600 [Circle 339]

# 12-BIT CONVERTER ALSO TRACKS, HOLDS AT 1 MHz

Analog Devices' 12-bit analog-to-digital converter combines high-speed data conversion and internal track-and-hold functions in a single hybrid package. The HAS-1201 operates at up to 1 MHz and offers capabilities that are comparable to board-level products but at a fraction of their price.

"In the past, you'd have to buy a separate track-and-hold circuit and 12-bit ADC and tie them together," says John Sylvan, the company's technical marketing specialist. "Now, you can just buy the HAS-1201, and all the specs are guaranteed." Using separate components would cost about $435, Sylvan says, and comparable board-level products can run as high as $3,000. The company designed the package for the system designer who needs to perform the entire ADC function in the smallest possible space.



**COMPLETE.** Analog Devices' 12-bit hybrid tracks, holds, and converts analog signals of up to 1 MHz.

Suitable for radar, medical instrumentation, and test systems, the HAS-1201 provides up to 4,096 encode commands for complete 12-bit ADC functions. Including the track-and-hold and timing circuits with the converter ensures accurate signal conversion through 1 MHz. Aperture time (delay) is 30 ns.

The linearity of the HAS-1201 is specified at ±½ least significant bit, with guaranteed monotonicity over the specified operating temperature range.

The HAS-1201 comes in three versions, with the HAS-1201KM specified for operation over a 0°C to +70°C case-temperature range. Both the HAS-1201SM and the HAS-1201MB versions are rated from –25°C to +85°C, but will continue with degraded performance from –55°C to +100°C.

**CRITICAL SPECIFICATIONS.** The converter accepts bipolar or unipolar 5- or 10-V signals with 1,000- or 2,000-Ω input impedance, respectively. In high-speed applications, for which dynamic specifications are even more critical than dc performance, the HAS-1201 offers typical in-band harmonics of 80 dB, with a 68-dB signal-to-noise ratio and a 30-ps aperture uncertainty. The typical ±3-dB bandwidth for the converter is 2 MHz for both small and large signal inputs.

Digital outputs for the HAS-1201 are TTL-compatible, and output coding is straight binary, offset binary, or 2's complement.

Prices for the HAS-1201 start at $395 in lots of 100 pieces; the 1201SM and 1201SMB are priced at $569 and $692 each, respectively, in like quantities. Delivery is from stock. All three versions of the HAS-1201 come in 2.4-by-1.6-by-2.0-in. hermetically sealed metal packages and use standard supply voltages of ±15 V, +5 V, and –5.2 V. Power consumption is 3.0 W. *–Debra Michals*

Analog Devices Inc., 2 Technology Way, Norwood, Mass. 02062.
Phone (617) 329-4700 [Circle 340]

# AMD PACKS PROMs WITH DIAGNOSTICS

On-chip diagnostics, in the form of a serial shadow register (SSR), have been added to Advanced Micro Devices Inc.'s line of 4-bit-wide registered PROMs. The shadow register, so named because it is undetectable unless activated by the user, enables board designers and service technicians to find hardware-related system problems quickly and systematically within a single system cycle.

The family consists of three bipolar parts—Am27S65A, Am27S75A, and Am27S85A—that contain two 4-bit registers each and 1-, 2-, and 4-K-byte capacities, respectively. System cycle times are 33, 37, and 39 ns, respectively. These registered PROMs complete AMD's on-chip diagnostics family, which includes a registered static RAM, the Am9151, and a fuse-programmable controller, the Am29PL141.

In the diagnostic mode, users can set the state of the regular register, clock the system, and follow data through the system to pinpoint where data changed incorrectly. "Without the serial register, you might need to cycle a system 65,000 times to get enough information for analysis," says Chris Henry, marketing manager for registered PROMs. "With these diagnostics, you need to cycle your system only once."

**HALF THE POWER.** All parts come in 24-pin, 300-mil-wide ceramic and plastic packages, which occupy about one third the board space of standard discrete PROMs and registers. They are also available in plastic DIPs and leadless chip carriers. Also, the company claims the PROMs consume 50% less power than separate PROM and register combinations, and they use platinum-silicide fuses that increase reliability and programming yields, the company says.

Although the company says adding on-board diagnostics "slightly increases" the price of these PROMs, Henry and product marketing engineer Erik Cleage say the savings in time and components will make up for the few extra dollars.

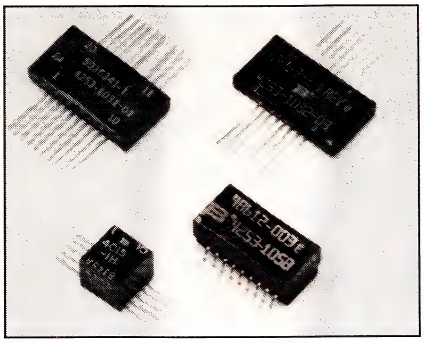
"As system complexity increases, it becomes much harder to find problems in board designs," says Cleage. "Designers spend about 40% of their time in layout, and the other 60% finding errors. Companies usually end up swapping out faulty boards instead of fixing them, because it takes so much time, so there's always a roomful of boards that no one ever gets around to." He says that on-chip diagnostic capabilities, which are of "special significance to production-line managers, program managers, and repair personnel," will help solve these problems.

The Am27S65A, Am27S75A, and Am27S85A are in production and can be ordered now. In orders of 100 pieces, the PROMs sell for $18.50, $29.00, and $46.00, respectively. *–Denise Caruso*

Advanced Micro Devices Inc., 901 Thompson Pl., P. O. Box 3453, Sunnyvale, Calif. 94088. Phone (408) 732-2400 [Circle 341]

## TRANSFORMER IS SURFACE MOUNTABLE

The models 4253 and 4290 surface-mountable transformers suit applications requiring high-density pc boards. The 4253, a miniature pulse transformer, comes in both a medium-profile package and a flatpack configuration. The first package offers J-leads for direct soldering to boards. The flatpack's leads permit reflow-solder attachment.



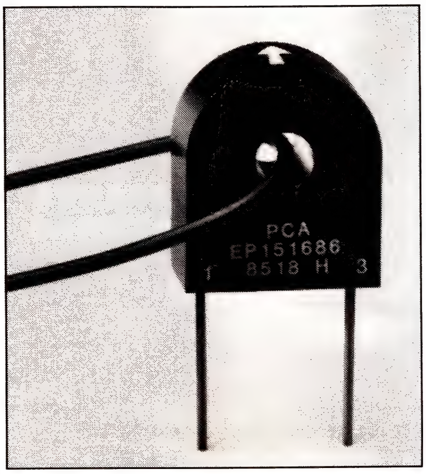
The 4290 is a subminiature pulse transformer designed as a low-cost, open-frame commercial device. It comes in a polyimide carrier with solder pads for reflow-soldering. Commercial-grade versions of the 4290 range from $25 to $50 in lots of 1,000 pieces or more.

Bournes Inc., 1200 Columbia Ave., Riverside, Calif. 92507.
Phone (714) 781-5071 [Circle 351]

## TRANSFORMERS SENSE CURRENTS AT 50 kHz

The EP150000 series of current-sensing transformers enables the designer to add on-board current sensing for applications ranging from power supplies to electronic motion control.

For power-supply applications, the current transformer can replace power-dissipating resistors. Its frequency response of 20 to 50 kHz allows it to be used in switching power supplies that operate over the same frequency.



Peak current sense for the transformers is up to 20 A, and they operate from –10°C to +125°C. Intended for pc-board mounting, the transformers come in a transfer-molded epoxy package. A 0.17-in. hole allows insertion of the wire whose current is to be sensed. The EP150000 transformers cost $3.00 in quantities of 1,000. Delivery takes 6 weeks.

PCA Electronics Inc., 16799 Schoenborn St., Sepulveda, Calif. 91343.
Phone (818) 716-7922 [Circle 352]

## FAST OP AMP WORKS IN LOW-GAIN DESIGNS

The CLC231 Buff-Amp solves the high-speed, low-gain tradeoff encountered with other operational amplifiers, the manufacturer claims. The part operates at gains of ±1 to ±5, thus making it a low-gain design alternative to low-precision open-loop buffers and oscillation-prone conventional op amps. The op amp boasts a 12-ns settling time.

The Buff-Amp features a 95-MHz full-power bandwidth and a high output drive. Applications include communications and instrumentation. The CLC231 is specified for a 100-Ω load, thereby freeing the designer of having to interpret a data sheet that assumes unrealistically large load resistances.

An 18-mA supply current enables designers to stay within thermal and power budgets, the company claims. The part can operate on supplies as low as ±5 V and 5 mA while retaining nearly half of the 165-MHz –3-dB bandwidth.

The CLC231 Buff-Amp comes in a 12-pin TO-8 package and costs $105 in 100-piece quantities. Delivery is from stock.

Comlinear Corp., P. O. Box 20600, Fort Collins, Colo. 80522.
Phone (303) 226-0500 [Circle 350]

## DEVELOPMENT SYSTEM HANDLES INTEL CHIPS

Now designers working with Intel Corp. microprocessors don't have to rely solely on the manufacturer for their development-system support. Access-IIe from Genesis is an economical "no-card-required" version of the company's Access-II development system.

The package, which sells for $495, runs on an IBM Corp. Personal Computer or compatible. The user doesn't need a plug-in card, but he does have to replace the computer's 8088 or 8086 with a supplied NEC Corp. V-20 or V-30 processor. Besides the V-20 or V-30 and emulation software, the package comes with the Net data-link program for transferring source-code and object-code files between the computer and an Intel de-

velopment system.

PC AT owners can get the Access-II package for $995. This Intel-compatible development system includes a plug-in card containing a Z-80 microprocessor and 64-K of RAM. Otherwise, the packages are the same. The manufacturer says that Access-II runs the Intel's Isis software much faster than an Intel development system does, while preserving the customer's investment in Intel software. Both Access-II and Access-IIe are available now.

Genesis Microsystems Inc., 196 Castro St., Mountain View, Calif. 94041.
Phone (415) 964-9001 [Circle 358]

## PROM PROGRAMMER WORKS FROM IBM PC

A development system for both PROMs and programmable logic arrays capitalizes on the popularity of the IBM Corp. Personal Computer in engineering environments. As many as four Allpro systems can be clustered to a single PC.

Every programming socket pin is software-programmable for voltage, current, and slew rate, so programming new parts requires only software updates. Upgrades for new devices can be installed by floppy disk or by modem transmission. Available now, the Allpro sells for $2,900. Soon Allpro will also be available in a completely stand-alone version, which will contain a PC-compatible motherboard.

Logical Devices Inc., 1321 N. W. 65th Place, Fort Lauderdale, Fla. 33309.
Phone (305) 974-0975 [Circle 378]

## CONVERTING ANALOG SCOPES TO DIGITAL

The Model 602 Dual Trace Scope Memory is an add-on device that converts a standard analog oscilloscope into a dual-channel digital storage scope. It functions as a conventional dual-channel storage scope or in a comparison mode that allows storing and comparing new waveforms on one channel against a standard stored on the other.

The instrument stores both analog and digital signals in a single sweep. It features 18 selectable sample times with a 1.4-MHz maximum sampling rate. Each input is selectable in eight ranges. Each channel has 2-K of memory for data storage.

The Model 602 costs $895. Delivery is from stock.

Sibex Inc., 3320 U. S. 19N, Suite 410, Clearwater, Fla. 33519.
Phone (813) 786-3001 [Circle 364]

## CARD TURNS A SCOPE INTO AN ANALYZER

The Spectrascope board, a plug-in with cables and the required software for an IBM Corp. Personal Computer and compatibles, uses the PC's computational power to convert a digitizing oscilloscope into a spectrum analyzer. Time-domain data is downloaded from the scope into the PC, then converted into frequency-domain data by the Spectrascope's software. Otherwise, the time-domain data can simply be displayed on the PC or stored on a floppy disk.

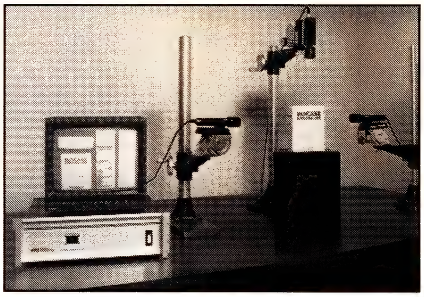
The user accesses Spectrascope by means of pull-down windows to calibrate the oscilloscope; then all subsequent displays are scaled and annotated automatically. A 0- to 50-MHz spectrum is possible with a 100-MHz scope. Spectrascope's dynamic range is over 90 dB, depending on the scope's specifications. Because it can capture and store a signal, the board enables analysis of single-event transients.

Spectrascope costs $695. Delivery takes four to six weeks.

Microsignal, P. O. Box 60312, Santa Barbara, Calif. 93160.
Phone (805) 964-2227 [Circle 363]

## DEVICE MIXES IMAGES FROM EIGHT CAMERAS

Framesplitter, a hardware device for machine-vision systems, combines the input from several solid-state video cameras into a single composite image.



Framesplitter processes up to eight camera inputs in a single step, boosting the speed of multiple-camera machine-vision systems. Without Framesplitter, such systems would have to process one video input at a time to gain a 360° view of a part.

Framesplitter sells for $5,300 and is available from stock.

Pattern Processing Technologies Inc., 511 11th Ave. S., Minneapolis, Minn. 55415.
Phone (612) 339-8488 [Circle 357]

## COMPUTER BOARD HAS BUILT-IN SASI

The Micro-20 single-board computer carries a Shugart Associates System Interface, which provides a large, flexible arrangement of peer-to-peer connections. A 16-bit expansion connector allows the systems integrator to add off-the-shelf or custom I/O interfaces. The board, which measures 8.8 by 5.8 in., mounts on and uses the same power connector and supply voltages as a standard 5¼-in. disk drive. The board also holds four serial ports, one 8-bit parallel port, and a floppy-disk controller.

The heart of the system is a 68020 microprocessor and an optional 68881 floating-point coprocessor with 2 megabytes of 32-bit-wide RAM and up to 256-K bytes of 32-bit-wide EPROM.

The price, in lots of 25, is $2,200; this includes a second board with RS-232-C-level translation and four connectors for the ports. Delivery is from stock.

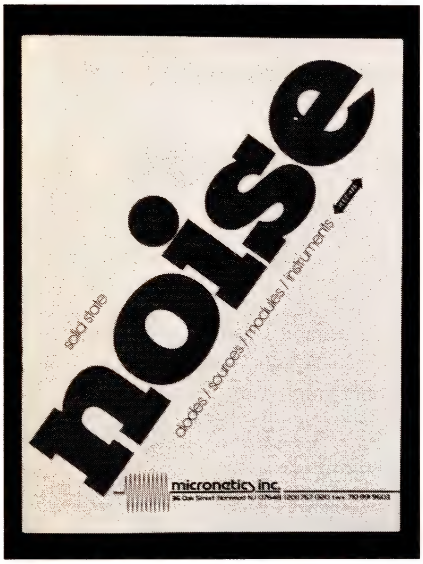
GMX Inc., 1337 W. 37th Place, Chicago, Ill. 60609. Phone (312) 927-5510 [Circle 359]

## 4-Mb MEMORY CARD FITS MICROVAX II

The QM-630 family of memory boards offers 2 and 4 megabytes of dynamic RAM on single quad-wide boards that fit an expansion slot on the MicroVAX II. The boards use Digital Equipment Corp.'s 32-bit-wide Q-bus, and are fully hardware- and software-compatible with the supermicrocomputer.

Data integrity is maintained through byte-parity generation and checking. The company, which also makes mass-storage systems for the Q-bus, lists the 4-megabyte QM-630 memory board at $2,495. Delivery is from stock.

Qualogy Inc., 2241 Lundy Ave., San Jose, Calif. 95131.
Phone (408) 946-5800 [Circle 362]



**NOISE.** A free 20-page catalog, "Solid-State Noise Diodes, Sources, Modules, and Instruments," details Micronetics' complete line, which covers audio frequencies to 70 GHz. The catalog gives design and application information on basic broadband types, high-output-level modules, and a full line of noise-source instruments, as well as noise diodes and chips. Another section describes the company's noise-source calibration services. Copies of the catalog are available by calling (201) 767-1320 or write to Micronetics Inc. at 36 Oak St., Norwood, N. J. 07648. [Circle reader service number 421]

**TRANSISTORS.** The *SOT-23 Transistor and Diode Selection Guide* and the *Super E-Line Transistor Technical Handbook* are free publications from Ferranti Semiconductors. The six-page product-selection guide features the Optimum-profile SOT-23, a surface-mounting package that permits users to clean and run interconnection lines underneath it. The 112-page handbook contains fully characterized data on devices with breakdown voltages specified to 300 V and collector currents specified to 2 A continuous, 6 A pulsed. Both are available from Ferranti Electric's Semiconductor Division, 87 Modular Ave., Commack, N. Y. 11725. Phone (516) 543-0200. [Circle 422]

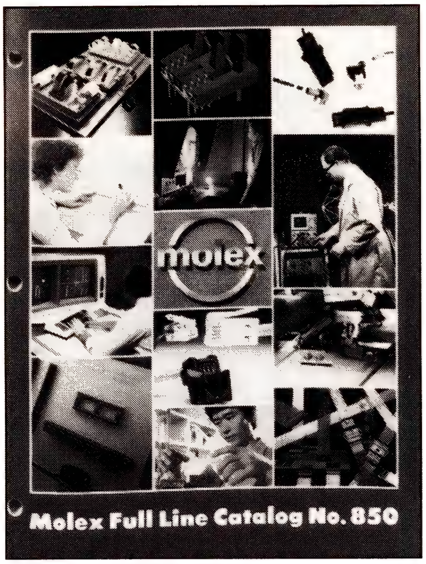
**EIA STANDARDS.** The Electronic Industries Association has published two new standards: Interim Standard No. 5-A, "Packaging Material Standards for ESD Sensitive Items" ($15 per copy), and Joint Electron Device Engineering Council Standard No. 22-A, "Test Methods and Procedures for Solid State Devices Used in Transportation/Automotive Applications" ($22). A new Jedec publication, No. 108, is titled "Distributor Requirements for Handling Electrostatic-Discharge Sensitive (ESDS) Devices" ($5). All are available from the EIA Sales Office, 2001 Eye St. N. W., Washington, D. C. 20006. Phone (202) 457-4981. [Circle 427]

**PRESSURE.** Over 150 pages of application notes make up the free *Pressure Sensor Handbook.* The applications reside in medical equipment, energy management, and automotive, avionic, and agricultural-electronics manufacturing. The notes describe SenSym Inc.'s IC pressure sensors and transducers including absolute, differential, and gauge types from 0 to 1 psi and up to 5,000 psi. One section discusses accuracy and autoreferencing. Write to the company at 1255 Reamwood Ave., Sunnyvale, Calif., 94089 for a copy, or call (408) 744-1500. [Circle 423]

**DATA COMMUNICATIONS.** Wideband and short-haul modems, data-over-voice and data-service units, and network-performance analyzers are among the new products featured in this 24-page catalog. Previously released products include the Omnimode series of intelligent modems and Datacryptor data-encryption devices. Catalog 3C697 is free from Racal-Milgo, MS D214, P. O. Box 407044, Fort Lauderdale, Fla. 33340. Phone (305) 475-1601. [Circle 424]

**ENTREPRENEURSHIP.** "Starting a High Technology Company—Strategies for Success" draws on interviews with the founders and senior managers of high-tech companies, so its advice to the would-be startup is based on solid experience. All too often, the difficulties appear simply too great, the interviewees say, discouraging many entrepreneurs who have no developed product to offer potential investors. Instead of rehashing methods of acquiring cash or lines of credit that work only for the "haves," this booklet suggests alternative paths—from identifying the product to drawing up a business plan that will attract capital, and, finally, manufacturing and daily operations. The booklet comes free from Deloitte Haskins & Sells High Technology Group, 128 Queen Victoria St., London EC4P 4JX; or from nominated high-tech branches of Barclays Bank. [Circle 434]

**INTERCONNECTION.** A full-product line for 1986 from Molex Inc. has sections on 0.1-in.-centerline modular interconnection systems; 0.5-in.-centerline ribbon-cable connectors; pc-board interconnection systems and edge connectors; fiber-optic links, telecom, and modular-I/O connectors; flat flexible-circuitry connectors; various sockets and receptacles; and solderless terminals. Write to the company at 2222 Wellington Ct., Lisle, Ill. 60532 and ask for catalog 850. Phone (312) 969-4550. [Circle 426]



**DATA BOOKS.** The following companies are offering their most recent data books:

*1985 Gate Array Databook.* Gould/AMI Semiconductors, 3800 Homestead Rd., Santa Clara, Calif. 95051.
Phone (408) 246-0330 [Circle 428]

*June 1985 Full Line Catalog.* Micro Power Systems Inc., 3100 Alfred St., Santa Clara, Calif. 95050. Phone (408) 727-5350 [Circle 429]

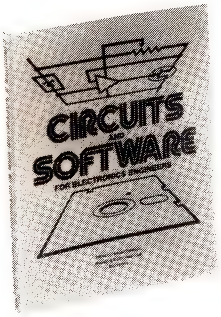
*1986/1987 IC Data Book—Linear and Conversion Products.* Precision Monolithics Inc., 1500 Space Park Dr., P. O. Box 58020, Santa Clara, Calif. 95052. Phone (408) 727-9222 [Circle 430]

*PF474 Product Data Book.* Proximity Technology Inc., 3511 N. E. 22nd Ave., Fort Lauderdale, Fla. 33308.
Phone (305) 566-3511. [Circle 431]

*Linear Integrated Circuits.* Raytheon Co., Semiconductor Division, 350 Ellis St., Mountain View, Calif. 94039.
Phone (415) 968-9211 [Circle 432]

*VLSI Data Book.* TRW Electronic Components Group, LSI Products Division, P. O. Box 2472, La Jolla, Calif. 92038. Phone (619) 457-1000 [Circle 433]

**SEMICONDUCTORS.** A 24-page catalog from Mitsubishi Electronics America Inc.'s Semiconductor Division highlights the company's expanded power-module line and optical products. It also indexes memory products, microcontrollers and microprocessors, logic products, interfaces, and gate arrays. One section describes IC packages. For a free copy, contact the literature administrator at (408) 730-5900, or write to the company at 1050 E. Arques Ave., Sunnyvale, Calif. 94086. [Circle 425]



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*MEETINGS*

# BUSCON TO BOW AS SHOW FOR BUS SYSTEMS

**SAN JOSE**

Buscon/86 will mark "the first time that all bus systems people have been under one roof," says Ed Grazda, education director of Buscon Inc., the privately incorporated organization that puts on the show. Buscon's 32 papers and six seminars will cover such topics as standard and advanced buses and the Manufacturing Automation Protocol.

Conference attendees will hear about the advantages and disadvantages of various advanced bus systems in presentations on Multibus II, VMEbus, NuBus, Fastbus, and Futurebus. One key presentation will be given by Paul Borrill, who will compare the major 32-bit buses. Borrill, the technical manager for Spectra-Tek UK Ltd. and chairman of the IEEE group working on Futurebus, claims that "Futurebus is clearly the technical leader." He chaired the Multibus II committee until recently and was one of the authors of the VMEbus specification.

Borrill considers Futurebus the most suitable system for multiprocessing, partly because it handles cache memory better than the others. Paul Sweazey of Tektronix Inc., Wilsonville, Oregon, will deliver a paper on the Futurebus Caching System that he helped develop.

Borrill admits readily that the 32-bit commercial battle is between VMEbus and Multibus II because of the heavy product support each has mustered. "People don't always have time or the ability to figure which bus is best," Borrill says. Yet he thinks Futurebus will get more attention in a couple of years "after everyone has experience using one multiprocessing system."

**Buscon/86,** MultiDynamics Inc. (Anne Weber, Buscon/86, 17100 Norwalk Blvd., Suite 116, Cerritos, Calif. 90701), Convention Center, San Jose, Calif., Jan. 15-16.

**The MAP Users' Group Meeting,** Society of Manufacturing Engineers (1 SME Dr., Dearborn, Mich. 48121), Sheraton Centre, Toronto, Jan. 15-16.

**1986 Winter Usenix Technical Conference,** Usenix Association (Usenix Conference Office, P. O. Box 385, Sunset Beach, Calif. 90742), Marriott Hotel-City Center, Denver, Jan. 15-17.

**Forum '86,** Recognition Technologies Users Association (P. O. Box 2016, Manchester Center, Vt. 05255), Dallas Marriott Hotel, Dallas, Jan. 19-22.

**O-E/Lase '86,** International Society for Optical Engineering (P. O. Box 10, Bellingham, Wash. 98227-0100), Los Angeles Marriott and Airport Hilton hotels, Jan. 19-24.

**ASEE '86:** Advanced Semiconductor Equipment Exposition & Technical Conference (Cartlidge & Associates Inc., 1101 S. Winchester Blvd., San Jose, Calif. 95128), San Jose Convention Center, Jan. 21-23.

**World Conference on Electronic Printing and Publishing,** George Washington University (Henry B. Freedman, Electronet Information Systems Inc., 2000 Pennsylvania Ave. N. W., Washington, D. C. 20006), George Washington University, Jan. 22-24.

**1986 SCS Multiconference,** Society for Computer Simulation (Simulation Councils Inc., P. O. Box 2228, La Jolla, Calif. 92038), Bahia Hotel, San Diego, Jan. 23-25.

**Crosstalk '86,** EIA (EIA, Crosstalk '86, 2001 Eye St. N. W., Washington, D. C. 20006), Hyatt Palm Beaches, West Palm Beach, Fla., Jan. 26-29.

**1986 Reliability and Maintainability Symposium,** IEEE (Norman Kutner, Westinghouse Electric Corp., 401 E. Handy Ave., Sunnyvale, Calif. 94088), Riviera Hotel, Las Vegas, Jan. 28-30.

**Communications Networks '86,** CW Communications Inc. (P. O. Box 880, Framingham, Mass. 01701), Washington Convention Center, Washington, Jan. 28-31.

**ASTM International Symposium on Semiconductor Processing,** American Society for Testing and Materials (1916 Race St., Philadelphia, Pa. 19103), Red Lion Inn, San Jose, Calif., Jan. 28-31.

**Robotic Industries Association Meeting,** Robotic Industries Association (P. O. Box 1366, Dearborn, Mich. 48121), Sheraton, Scottsdale, Ariz., Jan. 29-31.

**RF Technology Expo,** RF Design magazine (Jim MacDonald, RF Design, 6530 S. Yosemite St., Englewood, Colo. 80111), Anaheim Hilton and Towers, Anaheim, Calif., Jan. 30-Feb. 1.

**Aerospace Applications Conference,** IEEE (Warren Schwarzmann, TRW Inc., 4 Aurora Dr., Rolling Hills Estates, Calif. 90274), Four Seasons Lodge, Steamboat Springs, Colo., Feb. 1-8.

**Power Engineering Society Winter Meeting,** IEEE (J. G. Derse, 1030 Country Club Rd., Bedminster, N. J. 07921), New York Penta Hotel, New York, Feb. 2-7.

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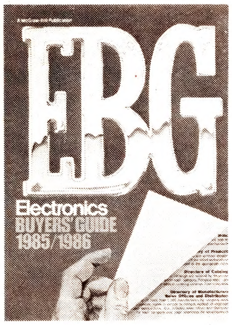
## 1985-86 Electronics Buyers' Guide



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# ELECTRONICS WEEK®

## FIAT, DEC FORM AUTOMATION TEAM

**C**omau, the robotics subsidiary of Italy's Fiat SpA, and Digital Equipment Corp. have decided to team up to market factory-automation systems. Their 50-50 joint venture, to be called Sesam, will base its products on flexible manufacturing systems from Fiat and data-processing equipment from DEC, of Maynard, Mass. The two companies are projecting sales for their venture of more than $200 million by the end of the decade with an established employee base of some 200.

## APPLE ANNOUNCES RECORD EARNINGS

**A**fter a tumultuous year that saw the resignation of its cofounder Steven Jobs, the closing of half its factories, and the laying off of more than a fifth of its work force, Apple Computer Inc. has announced record earnings for the current quarter. The Cupertino, Calif., company says it expects net income for its first fiscal quarter, ending Dec. 27, to be $52 million, a 13% increase over the $46 million it earned in the same quarter a year ago. Analysts point out, however, that the increased earnings were carried on the back of the corporate cutbacks and not on sales, which actually decreased from $698 million for the quarter in 1984 to $525 million this year.

## 1985 A LOSER FOR TANDON

**T**roubles continue for the recession-plagued personal computer industry. Particularly hard hit is Tandon Corp. The Chatsworth, Calif., disk-drive maker last week reported a loss of $135.4 million for its 1985 fiscal year on $268.8 million in sales, a 30% drop from 1984. The tide of red ink—far greater than financial analysts had expected—largely stemmed from $137 million in inventory write-downs of unsold drives, the company says. What especially hurt was a cutback by IBM Corp. of its drive purchases to only $91 million for the year, from about $232 million. Tandon has moved to free itself from heavy reliance on IBM by producing its own personal computers. The company says it has contracts to deliver $300 million in personal computers and work stations to two companies beginning in mid-1986, but declined to identify them.

## SNAG DEVELOPS IN MILITARY SWAP

**T**he first transfer of military technology from Japan to the U. S. is being delayed by negotiations over the reported $37 million price tag. That's the asking price for a missile-guidance system developed by the Japan Defense Agency that reportedly is more reliable than conventional radar-homing and infrared heat-seeking systems.

## FAIRCHILD WORTH CUT $485 MILLION

**S**hareholders of Schlumberger Ltd. took it on the chin when the French industrial conglomerate devalued its Fairchild Semiconductor Corp. subsidiary by $485 million. Fairchild had been valued at about $800 million on Schlumberger's books; the cuts include $250 million in "goodwill" (the premium paid over book value when the French company bought Fairchild in 1979), plus more than $100 million for disposal of obsolete buildings and equipment. In cleaning up Fairchild's balance sheet, the fourth-quarter earnings of Schlumberger shares were cut $1.62. The action should not affect the operations of the Cupertino, Calif., semiconductor manufacturer. Fairchild president Donald Brooks says Schlumberger remains firm in its support and "will continue to fund Fairchild. They will be investing [in Fairchild] for the next two years."

## MOTOROLA SETTLES SUIT AGAINST UTC

**M**otorola Inc., Schaumburg, Ill., and United Technologies Corp., Hartford, Conn., have quickly settled out of court a federal lawsuit that alleged infringements of 68000 microprocessor patents. Motorola charged that UTC had released confidential material on the 68000 family while operating Mostek Corp., Carrollton, Texas, a second source for the 16-bit microprocessor [*Electronics,* Dec. 16, 1985, p. 88].

## PHILIPS UNIT LEAVING DALLAS

**"B**ig D" has also stood for departure of computer company operations from Dallas. The latest to move a subsidiary headquarters from Dallas is Philips Information Systems, part of Philips of the Netherlands. The subsidiary, which markets word-processing, personal computer, and office systems, will move to Washington by mid-1986 to be closer to its governmental customer base. Dallas has also seen pullouts of computer subsidiaries and assembly plants by Harris, Xerox, and Apple Computer.

## XIDEX BUYS INTO SPUTTERED MEDIA

**X**idex Corp., Mountain View, Calif., increased its penetration in the sputtered-media business by acquiring Trimedia Corp. of nearby Fremont. Xidex, a diversified data-storage manufacturer, had a small sputtered-media operation but says that Trimedia was six months ahead in the technology. Trimedia, a 1983 startup, is one of the leading suppliers of sputtered media. It's the third acquisition in two months for Xidex. It paid $52.9 million for Charlton Associates of Irvine, Calif., a manufacturer of 5¼-in. hard disks, and more than $55 million for Control Data Corp.'s Peripheral Products division in Minneapolis.

## COMPUTERLAND SETTLES DISPUTE

**T**wo Computerland Corp. franchisees have been named to the company's board of directors in the aftermath of a legal agreement severing the Hayward, Calif., retailer from a court battle over Computerland stock owned by William Millard, its founder. Under the agreement, Millard quit as board chairman and investors Micro/Vest, the other litigant, agreed to release Computerland from liability in its suit.

## GCA REACHES LOAN AGREEMENT

**S**emiconductor manufacturing-equipment maker GCA Corp., which recently defaulted on loans, has reached an agreement with its lenders to raise additional capital. The Bedford, Mass., company will defer interest payments due over the next six months and sell its Instruments and Equipment Group based in Chicago as well as real estate holdings. The package should raise about $20 million, says a GCA spokesman, adding that despite rumors, the company had no interest in being acquired. GCA now expects its fourth quarter loss will likely exceed the $27.4 million loss in the third quarter.

## ASAHI CHEMICAL ADDS LSI LAB

**A**sahi Chemical Industry Co., Osaka, Japan, is expanding its entry into electronics with the opening of a large-scale integrated-circuit research and development laboratory in Atsugi, a Tokyo suburb. Asahi has hired 50 engineers to develop manufacturing capability and products as well as to design gate arrays.

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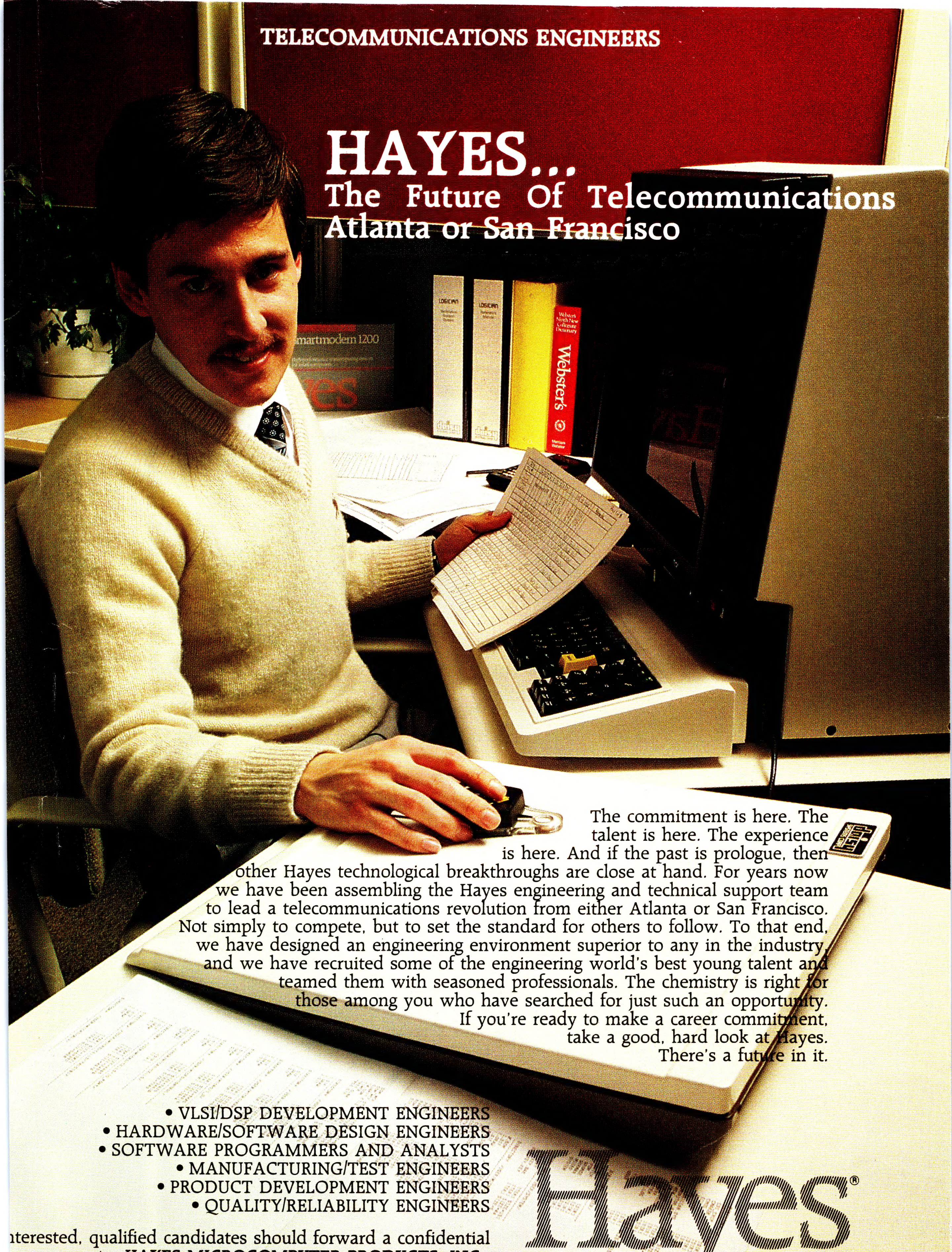

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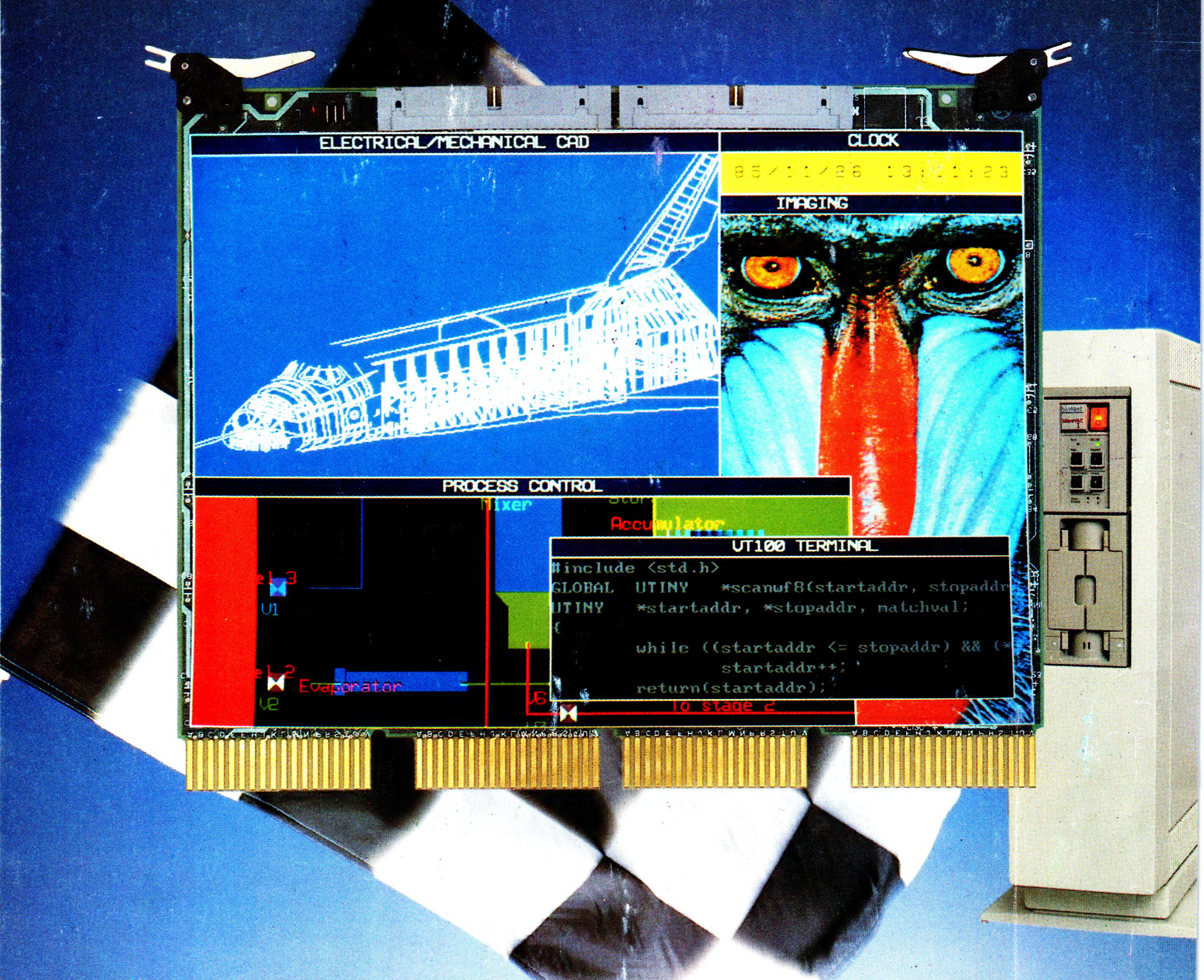

```
#include <std.h>
GLOBAL  UTINY   *scanwf8(startaddr, stopaddr
UTINY   *startaddr, *stopaddr, matchval;
{
        while ((startaddr <= stopaddr) && (*
                startaddr++;
        return(startaddr);
```

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